MILITARY SYSTEMS DESIGN

SEPTEMBER-OCTOBER 1961

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Tantalum Capacitors

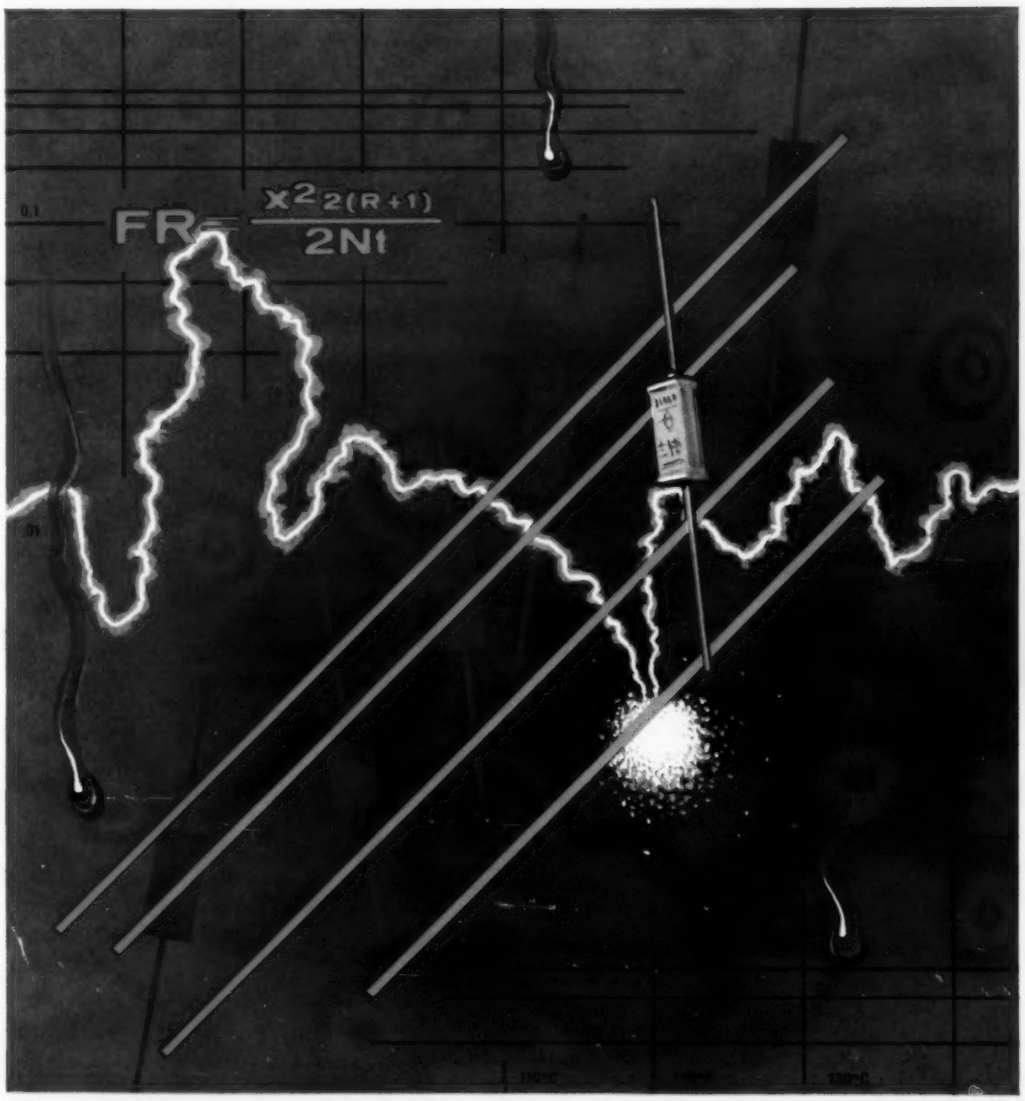
Design of an FM/FM Telemetry Discriminator

Confidence Limits for Subsystem Reliability

Electronic Circuitry

cover article

The Evaluation of a Low Cost, Standard Reliability Program



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COVER: Accelerated Life Tests as described in Edmund A. Bolton's article (page 8) on ceramic capacitor manufacture is inspiration for this illustration. This article describes a new standard reliability program which anticipates the tightened military reliability requirements foreshadowed by the Darnell Report.

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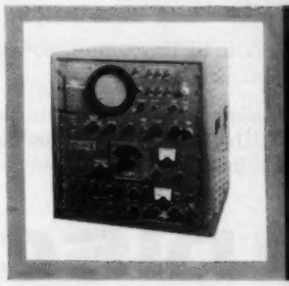

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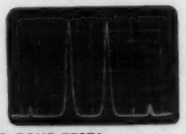

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Fixed sweep width 2000 cps. Full scale log sideband tones 1.5 kc and 2.1 kc from carrier (not shown). Odd order I. M. distortion products down 37 db.

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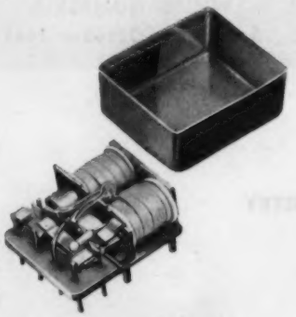


Filtors' Pillbox relays are designed to switch 16 times more power at 115 volts, 60 cycles, than any other microminiature relay.

Documentation, describing the nature of the phenomenon of discharge transients in grounded-case relays, is available from your Filtors' sales representative, or it may be obtained by circling the number given below on the inquiry card.

DANGER DISCHARGE TRANSIENTS

CIRCLE 3 ON READER-SERVICE CARD

One-way Reciprocity?

A more realistic reciprocal policy in world trade was recently urged in a hearing before the House Subcommittee on the Impact of Imports and Exports on American Employment by Mr. Robert C. Sprague, Board Chairman of the Sprague Electric Co., North Adams, Mass.

"For many years and in both Republican and Democratic administrations, relief from steadily lowered import duties has amounted to little more than words in the escape and peril point provisions of the Reciprocal Trade Agreements Act," Mr. Sprague said, referring to the practice of the Tariff Commission and the President in frequently denying relief permitted by law even after substantial damage has been shown.

Expressing the hope that Congress in 1962 will recognize the need to adopt a more realistic attitude toward World Trade when it considers renewal of the Trade Act, he said, "At least we should adopt a truly reciprocal policy on international trade in lieu of what is now often a one-way street."

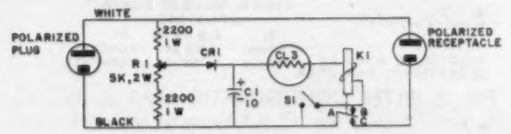
He pointed out that unemployment attributable to foreign competition has largely been local and restricted to companies, mostly small, which have been hard-hit by imports from low-wage countries. Although conditions in the electronics industry now reflect trends toward expansion and rising demands for defense products, "it is to such growth industries and electronics that our nation must look for alleviation of its unemployment problem. I think you gentlemen should consider whether unrestricted imports from countries with very low wage rates will not prevent an absorption of many of the unemployed."

A few Japanese businessmen have offered to furnish American manufacturers "with almost undetectable copies of parts now being purchased in this country at prices well below the lowest available from the U. S. producers." Mr. Sprague pointed out that Japanese electronic manufacturing facilities, built in

Letters to the Editor

Editor, MSD:

Referring to the circuit, "Photo-Resistor Triggers Relay," which appeared in the May-June issue of MILITARY SYSTEMS DESIGN, the term "isolation transformer" is a misnomer in that the secondary is connected to the primary through the load or contact A-C. This being the case, it is quite easy to rearrange the circuit as below to eliminate this transformer entirely.



Polarized plugs and sockets are shown in accordance with the requirements of the National Electric Code to prevent personnel hazards. If the chassis is to be grounded, a third green wire should connect the chassis ground with the grounded terminal, using approved 3-wire plugs.

E. U. Thomas, Ridge Rd., Syosset, N. Y.

Author's comment:

Mr. Thomas's suggestion for elimination of the isolation transformer is sound. However, I would recommend that the entire circuit should be isolated from chassis ground for maximum protection to the operator. His suggestion for use of polarized three-wire plugs and receptacles would be particularly appropriate in this case.

Chas. Caringella, P. O. Box 1025, Ontario, Calif.

Editor, MSD:

I read with great interest the article by Mr. F. Lemus, "Reliability Evaluation of a Satellite Power-Supply System," in the March-April, 1961, issue of MILITARY SYSTEMS DESIGN. Mr. Lemus has clearly shown how to determine the mean-time-between-failures for various configurations of components in parallel. However, I believe it is necessary to point out that his method is applicable only in a case in which a parallel component configuration is allowed to fail without replacement of one or more of the components. This may be true under laboratory testing for information only, or when the failure of one of the components in the configuration cannot be detected. However, in many cases, the failure of one of the components can be detected in pre-flight or post-flight checks of airborne systems. In such a case the defective component is repaired or replaced and the equipment is restored to its initial status.

Under these circumstances the MTBF of the equipment is a function of the mission time. It can be calculated by determining the reliability of the equipment with Mr. Lemus' equations, and then entering a table of the descending exponential function with the reliability figure and the mission time to determine the operational MTBF.

Marvin Feinstein
Reliability Section, Quality and Reliability Dept.
GPL Division, General Precision, Inc., Pleasantville, N. Y.

The comments of the author follow:

The analytical method described in my article applies to any system, airborne or otherwise, where preventive maintenance during its operation cannot be applied. Prior to an aircraft's mission, for example, the formulas in the article would yield the average-time-to-failure and the probability of successful operation of one of its airborne systems during that mission. As Mr. Feinstein points out, questions regarding average-time-to-failure and probability of successful operation are only asked prior to each period of operation. Therefore, if all failed components in the aircraft's airborne system are replaced upon completion of each mission, the formulas given can be used over and over by merely shifting the origin of starting time. If preventive maintenance can be applied to a system during its period of operation, the mean-time-to-failure of parallel components would be increased beyond the values obtained by the formulas in my article—how much depending on how often preventive maintenance is applied. However, my article dealt specifically with a satellite power supply system where maintenance during its airborne operation is, of course, impossible. I wish to thank Mr. Feinstein for his comments.

F. Lemus, SHAPE Air Defense Technical Center
The Hague, Netherlands

One-Way Reciprocity Continued

part with American financial aid, are as modern as any in the world. Although in some cases they employ even more up-to-date methods of automation than their American counterparts, their wage and salary scales average about one-fifth of those in America even after numerous fringe benefits, now required, are taken into consideration."

Mr Sprague urged the subcommittee to recognize the reality of large wage differentials and to be ready to prevent the slow, piecemeal contraction of an industry which has possibilities for providing employment for many of our citizens. "The health of our economy should be deemed equal in importance to relations with our allies," he concluded.

• • • •

Although Mr. Sprague has focused his attention primarily on the employment aspects of foreign competition, the nibbling at selected segments of the American electronics industry also poses a substantial threat to the capability of the American industrial plant to support U. S. Defense. A healthy and competitive U. S. electronics industry is not only important in keeping abreast of the Russian state-directed electronics production, but we rely on it for an uninterrupted source of electronics systems and components in the event of world conflict.

The encouragement of industry in friendly countries is a powerful weapon in international relations. However, as Mr. Sprague has very fairly emphasized, we believe a consideration of the effect of the present World Trade Act policy on economy and military readiness of the U. S. is equally essential.

This unbelievably clear and sharp photograph of over 120,000 sq. miles of the earth's surface was shot from a Thor intermediate ballistic missile at an altitude of 300 miles, with a KINOPTIK 5.7 mm f/1.8 APOCHROMAT. Free from distortion and with an unsurpassed degree of clarity, definition and contrast, this extraordinary picture exemplifies the outstanding wide-angle coverage (113°) of this unique lens.

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18mm f/2	50mm f/2.8
20mm f/1.9*	75mm f/2
25mm f/2	100mm f/2
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Electronic Circuitry

A continuing MILITARY SYSTEMS DESIGN feature, these circuits are selected because they represent good design. Significant characteristics which are not self-evident from the diagram are explained in the printed commentary.

OPERATIONAL AMPLIFIER IS FOURIER COMB ELEMENT

Dc amplifier module (Fig. 1) is designed for use in a number of applications, including an active filter configuration with variable resonant frequency f_r and variable Q. Three amplifier modules with the two potentiometers, two capacitors and seven resistors shown in Fig. 2 make up a filter passing a single frequency. By assembling a Fourier comb filter (Fig. 3) from a number of such filters, with each filter tuned to a separate harmonic of the wanted signal, a signal with greatly improved signal-to-noise ratio can be reconstructed.

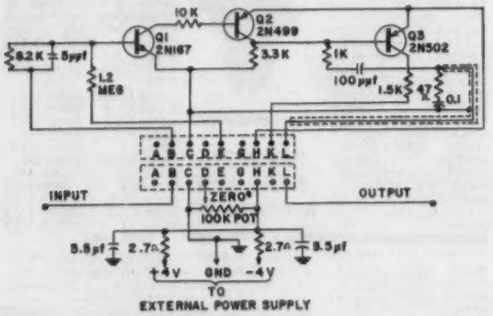


FIG. 1. DC COUPLED Operational Amplifier Module Schematic. Three are used in each filter. Zero pot shown is needed only when testing; not used in filter.

Characteristics of the amplifier shown in Fig. 1 are: Bandwidth, approx 4.5 kc; — voltage gain, $1400 > A > 1800$; Input resistance (R_{in}), approx 8.5 K; peak-to-peak output noise approx 1 mv; and dynamic output range ±4 v. Power required per module is 4 ma at 4 v dc. To obtain these characteristics, transistors Q_1 and and Q_2 must be selected in pairs so that $beta_2$ (I_{c2} at 1 ma) times $beta_3$ (I_{c3} at 3 ma) is not less than 1000.

Capacitor C_1 value (Fig. 2) is computed from the relationship $f_r = \alpha^{1/2}/2\pi\,\tau_1$ where f_r is resonant frequency, $\alpha^{1/2}$ is assumed to be unity, and $\tau_1 = R_1C_1$.

Computed values for C_1 at 50 cps and 100 cps are as shown in the legend below Fig. 2. C_t is picked for each filter so that, at resonance and at maximum Q position, voltage gain is approximately 250.

C_t functions as an additional lag (controllable) to compensate for the cumulative phase error of the two integrators. Since this phase error is a function of unfedback amplifier gain and phase at the filter frequency, explicit expressions are rather cumbersome and not too useful because of variations in open loop gain and frequency. Trimming via C_t is only necessary for very high Q filters, but for Q less than 250, retrimming is unnecessary over a 20% frequency range. Detailed analysis of circuit design is given in source article.

Source: Mr. R. A. Dandl, Oak Ridge National Laboratory, Oak Ridge, Tenn., also "Active Filter Element and its Application to a Fourier Comb," by F. T. May and R. A. Dandl, p. 387, Vol. 32, No. 4, *The Review of Scientific Instruments*, April 1961.

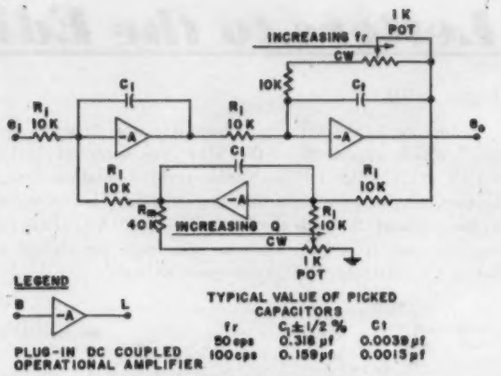


FIG. 2. FILTER CONFIGURATION. All resistors are ¾ watt, ±½%, ww. Cl is Vitamin Q and mica capacitors picked to within ± ½%. Ct is mica capacitor picked for each filter so that, at resonance and at max Q, voltage gain is approx 250.

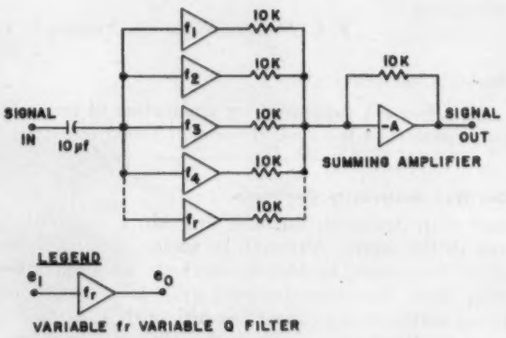
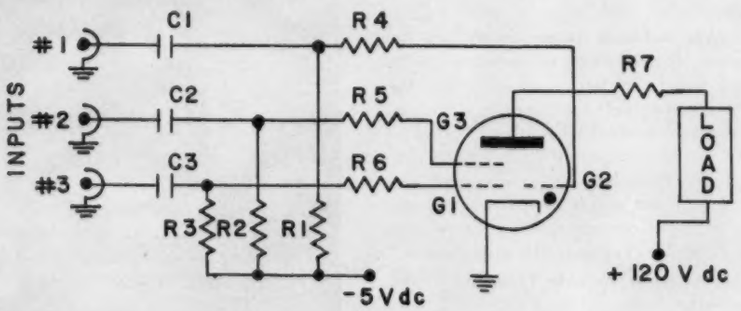


FIG. 3. FOURIER ANALYZER using five filters each of the type shown in Fig. 2. All resistors are ¾ w, ±½%, ww.

Triple Coincidence Control

The miniature Type KP-80 Triple Control Coincidence Thyratron is designed for use in coincidence control circuitry, including applications in nuclear research. The tube has two symmetrical ion deflection electrodes (grids 1 and 2), and a third ion formation electrode (grid 3). In double coincidence circuits G3 is connected directly to the cathode and two signals of 5 v minimum, coincidently applied to G1 and G2, are necessary to fire the tube.

In the triple coincidence circuit (see figure), three coincident signals of 5 v to each of the grids will fire the tube, while two coincident signals up to 20 v applied to any two of the three grids will not cause conduction.



Peak forward or inverse anode voltage is 500 v; peak cathode current is 100 ma. Operating plate voltage is from 90 to 150 v @ 25 ma average cathode current. Grid currents are 5 ma average. The tube uses a small button miniature 7-pin base; heater requires 150 ma @ 6.3v ac.

The values of the R-C input circuits will be determined by the amplitudes of the incoming pulses and the degree of discrimination required by the application. Typical values for most applications are: C1, C2 and C3, 0.01 µf; R1, R2 and R3, 10 K. The value of R7 also depends on the requirements of the application and should be high enough to limit the cathode current to a safe value. Once the KP-80 conducts, the grids lose control of the cathode current and interruption of the anode potential by some method is necessary to re-establish control. If circuit time-constants are made sufficiently short, the coincidence period can be limited within fractions of a microsecond.

Source: "Handbook of Essential Characteristics, Special Purpose Electron Tubes," KIP Electronics Div., York Research Corp., One Research Dr., Stamford, Conn.

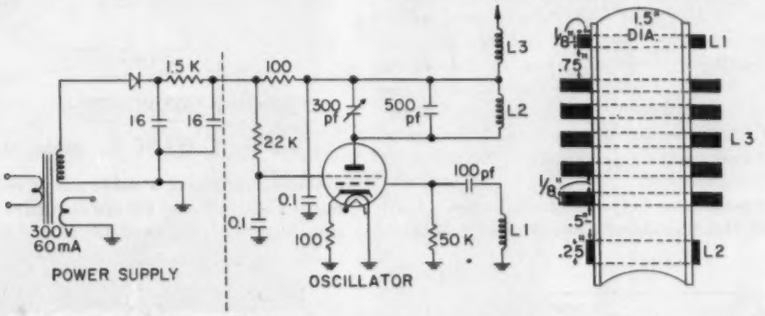
Electronic Vacuum Leak Detector

The RF oscillator shown below is designed as a convenient substitute for the high frequency Telsa coil commonly used to detect leaks in a glass vacuum system. It uses a standard television radio-frequency power transformer as the oscillator coil.

The power supply and oscillator are constructed each on a separate chassis, with the oscillator designed to be held in the hand to keep the high voltage lead as short as possible.

at 350 v dc. In one oscillator coil the construction was as shown in the detail at the right. L1 and L2 consist of 200 turns each, and L3 of 2000 turns of 38AWG enameled wire. The high voltage (probe) end of the 10kv secondary coil L3 must be well insulated. The outside cover of the oscillator unit should also be well insulated to prevent shocks to the operator from the 350 v dc supply.

The oscillator is tuned by varying C5 to give the maximum spark discharge, and will be left in this position. Output frequency is in the 50 to 100 kc range and



A rectifier diode with a PIV of approximately 1000 v and a capacity of 30 ma is required. The oscillator tube can be a 6V6, a 6L6 or any more modern equivalent. The power transformer must supply 6.3 v ac filament voltage to the oscillator tube and about 300v rms to the diode. The diode output required will be about 30 ma

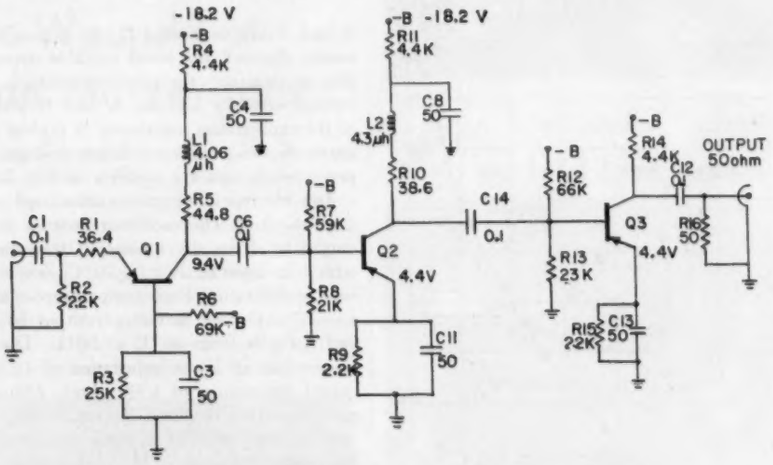
should not cause more RFI than the spark-gap Tesla arrangements normally used in this application.

Source: Dr. D. J. Dowling, Ph.D., Foliejon Park, Winkfield, North Windsor, Berkshire, England. Also *Journal of Scientific Instruments*, April 1960.

Shunt-Peaked Video Amplifier

A two-stage 2mc bandwidth video amplifier circuit having both input and output matched to 50-ohm impedance is shown. Gain bandwidth product of this amplifier has

bypass bias resistors R3, R9 and R15, while capacitors C4 and C8 serve as RF grounds to L1 and L2 respectively.
All resistors are ½ watt ±5%.
Overall Gain: 8.5

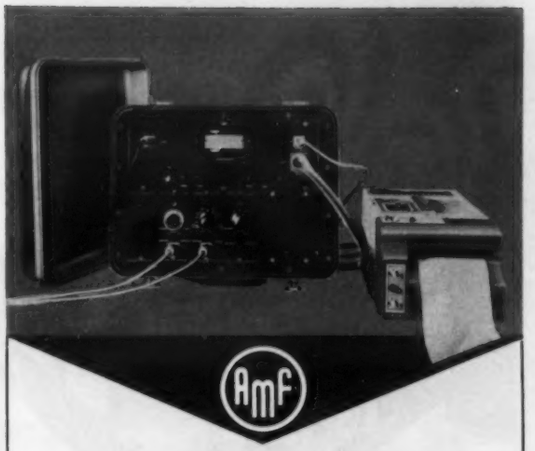


been experimentally determined as 17.9 mc. The common-base stage Q1 serves only to match the amplifier proper to the low impedance input, and has a current gain of 1. Stages Q2 and Q3 are common-emitter amplifiers having current gains of 3.13 and 2.74 respectively.

Shunt peaking for improved high-frequency response is placed between base and ground (or base and emitter) of Q2 and Q3. 50 μf electrolytic capacitors are used to

Input Impedance: 50 ohms
Output Impedance: 50 ohms
Power requirements: 7 ma at 18.2 v dc
Transistors are 10mc germanium PNP alloy-junction type similar to GT761.

Source: R. S. Pepper and D. O. Pederson, Electronics Research Laboratory, University of California at Berkeley, Calif.



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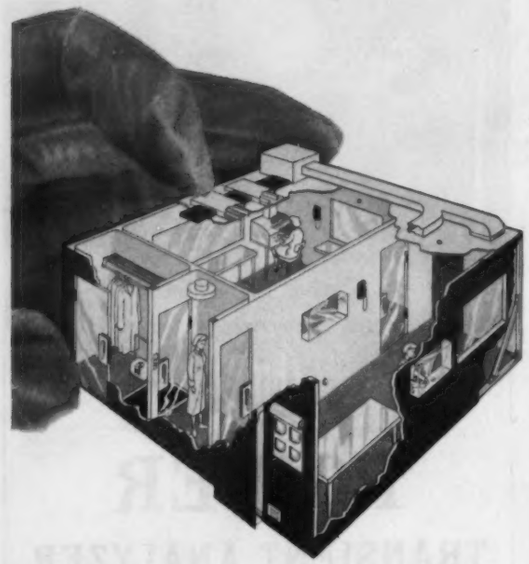

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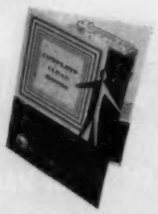


Controlled Environment, Inc.
915 GREAT PLAIN AVENUE, NEEDHAM 92, MASSACHUSETTS

CIRCLE 7 ON READER-SERVICE CARD

MISSILE PRESSURE-GAGE CIRCUIT

A rugged, sensitive pressure gage used in NASA upper-atmosphere rocket sounding is shown in Fig. 1. The flat diaphragm material is first firmly fixed to the perimeter of the corrugated backing and then formed by forcing it into the corrugations of the backing. This gage, with a full scale reading of 200μ Hg withstands an overpressure at one atmosphere of over 1500 times full scale pressure, with a max zero shift of 0.20 volts. At O μ Hg the gage has a sensitivity of 0.35v/μ Hg.

The reference vacuum is maintained by a re-usable getter, consisting of 15 cm of fine titanium wire, which is heated to incandescence less than 8 hours prior to flight. This absorbs all residual gasses to reduce the vacuum to less than 10^{-4} mm Hg. The output of the pressure gage is a capacitance between the center of the diaphragm and the capacitor plate Cg. Any change of this capacity is converted into a dc output by action of the ionization transducer, IT.

Operation of the Decker Corporation Ionization Transducer is unique. This transducer consists of an evacuated envelope containing a noble gas at reduced pressure. External plates P1 and P2 are energized by an ac potential generated by an RF oscillator (Fig. 2). Internal electrodes A and B are connected to the grounded side of the RF source through the small variable capacitor Ca and (in this application) the gage capacitance, Cg. A dc output voltage appears between A and B which is a function of the capacitance unbalance. A typical gauge calibration curve showing emitter-follower voltage outputs vs input pressures in mm Hg appears in Fig. 3.

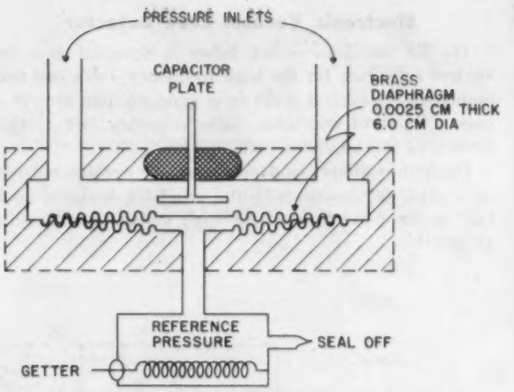


FIG. 1. GAGE for space near-vacuums

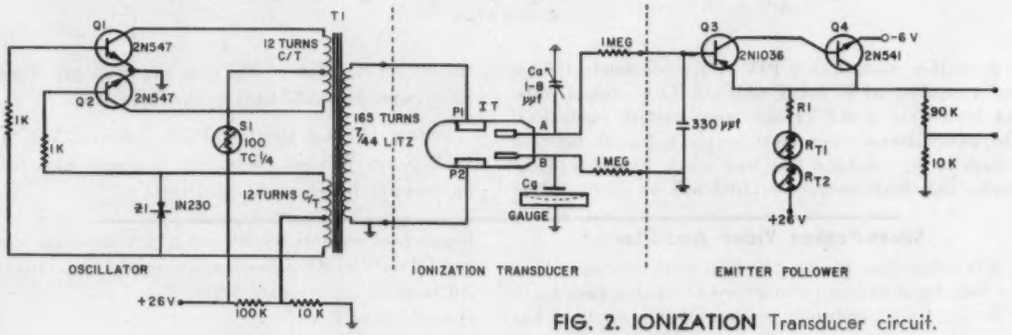


FIG. 2. IONIZATION Transducer circuit.

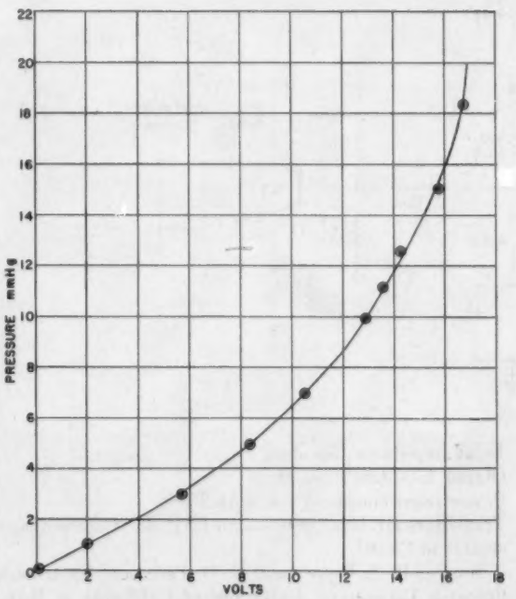


FIG. 3. GAGE Calibration Curve.

The electronic circuitry associated with the gage is transistorized. The oscillator portion furnishes a 290 kc output to drive the ionization transducer at 244v rms with a dc input of 26 v @ 70°C. Zener diode and thermistor stabilization limit temperature-caused variations to a —1.7% change in voltage output from 22°C to 35°C and +0.7% from 35°C to 50°C. The emitter follower circuit has an input impedance of 15 megohms and an output impedance of 1500 ohms. Although it has unity gain, it serves to drive the succeeding telemetry stages (not shown) without loading the ionization transducer. Frequency response of the emitter follower is 0-200 cps, noise level is 4 mv peak-to-peak average.

Power: RF Oscillator +26 v 32 ma
Emitter Follower +26 v 3 ma; —6 v, 2.5 ma.
Positive voltages furnished from missile battery, negative voltage requires separate battery.

Source: Final Report Contract NONR 3000 (00) (X), The Decker Corporation, Bala-Cynwyd, Penna.

Device Shows Reactance Effect in Resistors

The device illustrated is the "Scoparator," a reference gadget which enables design engineers to quickly compare typical scope traces of GB low reactance wirewound resistors with conventional wirewound and carbon film types.

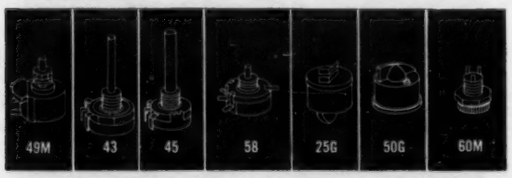
Actual photos taken on a Tektronix 545-A Oscilloscope have been reproduced on three separate transparent wheels to allow viewing of many different combinations of frequency, resistor type and resistance value. The traces were made by passing a square wave at the indicated frequency through each of the resistors, showing the reactive effect of the resistor on the signal. Thirty traces are provided for each of the three resistor types. The Scoparator is available on request from GB Components, Inc., 14621 Arminta St., Van Nuys, Calif.

FOR THIS LITERATURE CIRCLE 115 ON READER-SERVICE CARD

Wire-Wound Pots Include Mil-Versions

Fourteen different series of wirewound potentiometers, plus versions which meet military specifications, cover ratings from 1.5 watts to 50 watts power, and resistances from 0.5 ohm to 75,000 ohms. Derating curves for each series are shown below. Of particular interest in this respect are the high power Series 25G and 50G which derate to zero at 340°C and meet Mil-R-6749.

The Cap-Pot (Series 60M), which is a sealed unit mounting on the operating side of the mounting surface, may be used in pressurized equipment without the need



for expensive bellows or other pressure-sealing devices.—(*From new 12-page catalog EEM 4700 2-61 Section 3, Clarostat Manufacturing Co., Inc., Dover, N. H.*)

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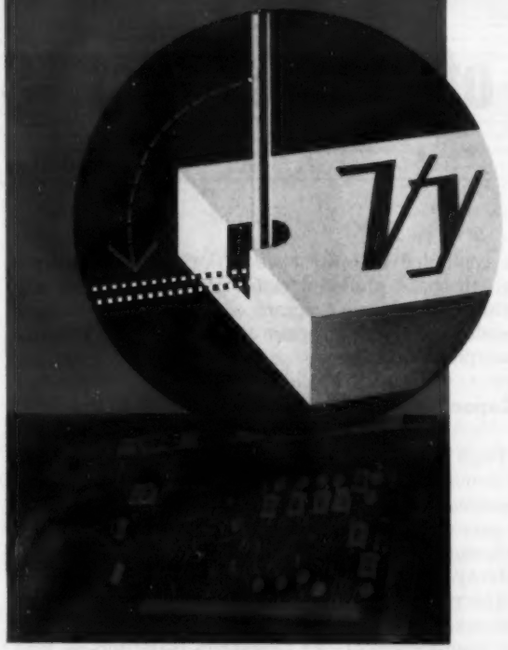

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**Assuming minimum allowance of ⅛" for lead bend at each end of body for axial capacitors*

CONFORMS TO MIL-C-11272B

Vy™ Axial-Radial Capacitors vs. Axial Lead Capacitors

VY 12 Axial-Radial Capacitor
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Board Space Required 3/8"
(No allowance necessary for lead bend)

VY 13 Axial Capacitor
Length 3/8"
Board Space Required 5/8"

Brand "X" Axial Capacitor
Length .11/32"
Board Space Required 19/32"

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CIRCLE 8 ON READER-SERVICE CARD

The Evolution of a Low Cost, Standard Reliability

EDMUND A. BOLTON
Manager, Applications Engineering
Vitramon, Inc.

AS MILITARY equipment has become more sophisticated, system reliability has generally suffered because of the vastly increased number of component parts required. In order to reverse this trend to lower reliability, the reliability of the components must be substantially increased. As a result, costs of advanced equipment have spiralled because higher parts costs are multiplied by increased numbers of components. Even ground equipment has felt the trend to higher cost because of higher reliability requirements. In the past, the penalty for failure of ground equipment was considered sufficiently lower than that in airborne applications that lower reliability could be tolerated. However, the increasing importance of ground equipment in the defense against missile attack, as well as the increasing complexity of the systems causing more costly downtime, has forced a re-evaluation in this area and established requirements for higher reliability.

Three possible courses are open to improve reliability without dramatic increases in costs. First, reliability often can be improved by designing circuits which allow wide drifts in component parameters before impairment of circuit function occurs. A second method is to utilize components with considerably higher ratings than required by operating conditions. Although derating normally improves reliability, extreme caution must be utilized, since some components, such as relays operating under dry circuit conditions, are less reliable if derating is utilized. The third distinct method of improving reliability is through a "standard reliability program". This third method is most intriguing because it takes advantage of the component manufacturer's intimate knowledge of his own product. Also, a high-volume/low-cost program is attainable since many customers orders may be combined to form a single lot. To illustrate not only the basic philosophies involved but also the evolution of a typical program of this type, consider a standard reliability program first offered by Vitramon, Incorporated in 1958.

Capacitor Fabrication to Standard Reliability Specification

High Reliability Specification S-1002 was designed to provide assurance of greater reliability than military specification requirements minimum cost, and also to provide checks on production controls and manufacturing processes which would improve the reliability of all porcelain capacitors.

The specification was tailored to take advantage of the unique production methods which are utilized in the manufacture of "VY" porcelain capacitors as well as to eliminate the most likely failure modes. All capacitors normally fail as a result of impurities in the dielectric material or as a result of physical imperfections in the dielectric. Dielectric impurities usually result in parametric failure such as excessive change in capacitance, high dissipation factor or low insulation resistance. However, in some materials, if the impurity content is high enough, parametric drift can rapidly cascade into complete catastrophic failure under high-voltage stress and temperature conditions.

Imperfections of a mechanical nature in the dielectric will usually result in catastrophic failures; however, these are nearly 100% culled out by high potential testing before capacitors are shipped. If an occasional imperfect dielectric is not culled out, subsequent high stress levels can cause either complete dielectric breakdown or can also result in parametric drift which will eventually cascade to catastrophic failure. In addition to these two common forms of failure, most capacitors have a few additional modes of failure which are specific to their dielectric materials and construction methods. Some plastic film capacitors, for instance, will fail very rapidly if the upper temperature limit is exceeded by a relatively narrow margin; paper capacitors can fail due to poor connection between the leads and the foil; tantalum capacitors are extremely sensitive to polarity and will fail rapidly if the ac ripple voltages are high; several types of capacitors will incur problems when exposed to various types of radiation.

Porcelain Capacitor Fabrication

In order to assure freedom from failure due to chemical impurities in porcelain capacitors, all materials are purchased to stringent quality specifications and inspected by Quality Control upon receipt. After the materials are blended, melted and quenched to make a glass frit, samples of raw materials are manufactured into capacitors. High reliability specification S-1002 requires that the sample capacitors made

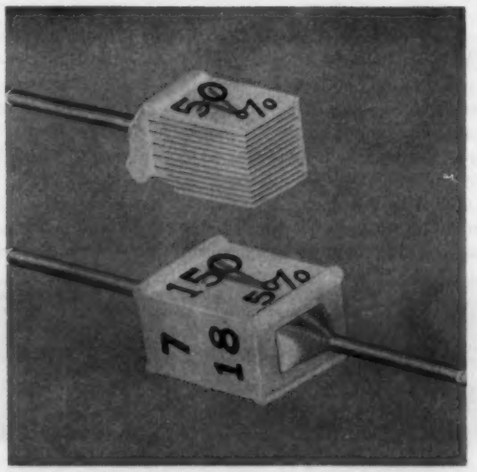
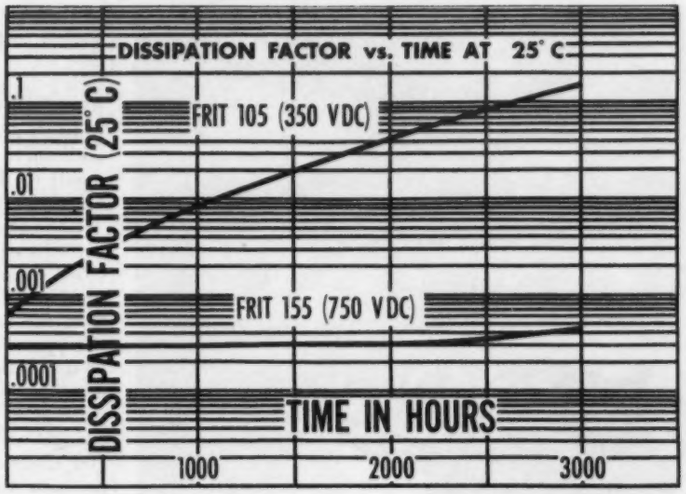


FIG. 1. **CERAMIC-SILVER** laminations of VY capacitors are fabricated in closely-controlled batches producing units having identical characteristics.

FIG. 2. ACCELERATED LIFE testing under high voltages is shown at right. Dissipation factors of Frit 105 (at 350 vdc) new Frit 155 tested at twice that valve are compared.



Program

from each batch of frit be tested for capacitance distribution, dielectric strength, dissipation factor at both 25°C and 125°C and temperature coefficient. Any impurities in the dielectric will be reflected in the dissipation factor measurements, particularly at high temperatures, and any error in the proportions of the formulation will show up in the temperature coefficient.

Approved batches of dielectric material are then milled with organic binders and cast into thin layers under closely controlled environmental conditions. Silver is silk-screened onto the layers of dielectric during laminating, with each print being separated by at least two discrete castings of dielectric (Fig. 1). All laminating is done on a batch basis. As many as 6000 capacitors are manufactured at the same time from approved batches of dielectric material and approved "high fine" silver.

Pre-Production Tests

Complete records are kept of materials, lots, operators and equipments. After the completed build-up is manufactured, the capacitors are cut apart from the overall matrix. This manufacturing method provides several unique advantages to a high reliability program. All capacitors of a given lot are manufactured from identical materials, by one operator, at one time. Because the location of each capacitor with respect to other units is known, it is possible to draw a sample from each area of the build-up to provide a lot sample which is truly representative. Since the characteristics of porcelain capacitors are unalterably fixed upon completion of firing, this sample taken from each build-up is submitted to the Quality Control Department for pre-production testing. Design, workmanship, electrical characteristics, capacitance distribution and overall quality are verified by a 250-hour accelerated life test. High Reliability Specification S-1002 requires that the sample from each build-up meet all requirements of these pre-production tests before any capacitors are released into the finishing operations.

Finished Product Life Tests

S-1002 also requires testing of finished capacitors. Every three weeks, samples are tested for barometric pressure, temperature and immersion cycling, moisture resistance, vibration, shock, terminal strength and solderability. Every six weeks a 300-piece sample, representative of the period's production, is drawn for longer term life tests. Comparison between finished product life testing and the earlier 250-hour life test provide continuing verification that the controls imposed by the specification are adequate.

Since 1956, 24 samples from every build-up of porcelain capacitors has been life tested at accelerated conditions to assure lot quality. Through early 1961 this testing program had encompassed over 32,000,000 unit-hours of life testing. Historically, the average failure rate on both accepted and rejected lots has averaged about 2.5% per 1000 hours at accelerated conditions. The finished product testing at rated conditions has encompassed about 7,000,000 component hours of tests. These finished product tests have produced no catastrophic failures, but have produced a parametric failure rate of approximately 0.2% per 1000 hours. Close correlation between failure rate in pre-production testing and finished product testing has been observed and documented in the paper "High Reliability Statistically Demonstrated" presented to the I.R.E. in March, 1959 by Barton L. Weller.

Further correlation has been provided by long term life tests on *reject* material. These tests have run for 30,000 hours at a temperature just slightly over 25°C with rated voltage applied. Table I compares the failure rate in the accelerated pre-production life tests with the failure rate on 30,000 hours of testing under these conditions.

Those lots with fewest pre-production test failures also had the lowest failure rate during the room temperature test, indicating the effectiveness of the pre-production testing program.

Changes in Standard Reliability Program

Although the original S-1002 has been an extreme-by successful program, three recent events have com bined to make a complete reappraisal of the standard higher reliability program desirable. First, the issuance of the Darnell report not only stimulated new, conceptual approaches to reliability but also portended a dramatic change in all future military specifications; second, three years of intensive research produced a modified porcelain dielectric material with vastly superior characteristics; third, MIL-C-11272 was revised to include porcelain capacitors and to specify measureably more stringent requirements.

The revised S-1002 and all standard high reliability specifications will undoubtedly follow the proposals of the Darnell report. Continuing plots of failures versus accumulated hours of testing will be maintained to guarantee failure rates. Unlike the original S-1002 which only guaranteed one failure rate based on the results of each lot tested, the new specification, S-1002B, will utilize cumulative figures to provide the reliability guarantee. The test conditions and post-test requirements will conform to or be more stringent than the military specification, providing for a considerably higher number of unit hours of testing than

TABLE 1—LIFE TEST ON REJECT MATERIAL

Lot No.	Catalog Number	Failure Rate Accelerated Life Test[1]	Failure Rate Rated Voltage-Temperature Test[2]
1330	CY17C751J-H	33%/1000 hrs	0
1307	CY32C182J-H	100%/1000 hrs	.278%/1000 hrs
1302	CY17C102J-H	100%/ 816 hrs	.139%/1000 hrs
1301	CY13C101J-H	67%/1000 hrs	0
1310	CY17C471J-H	67%/1000 hrs	.278%/1000 hrs
1339	CY22C681J-H	50%/1000 hrs	0

[1]Accelerated life test consisted of testing for 250 hours at 125°C and with 150% of rated dc voltage applied.
[2]Rated Voltage-Temperature Test consisted of 30,000 hours testing at 25°C and with rated voltage of the capacitor applied.

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in the original S-1002. This additional testing is included to provide finished product testing in a specific lot-by-lot basis (one week's production of each style) in addition to the lot qualification test. No parts will be shipped from the parent lot until the finished product test has confirmed lot reliability. In addition to normal post-test requirements, the requirements for the qualifications of each batch of frit will be retained.

Because the voltage for life testing in the new S-1002B will be twice the test voltage required in the older specification, reliability rates proven by the new specification will actually be ten times better than the same reliability rate under the test conditions previously employed. Fig. 2 shows a comparison of dissipation factor versus time for the old 105 frit material versus the newer 155 frit. The most critical parameters for capacitors in general are capacitance change with time and voltage, insulation resistance, and dissipation factor. In the case of porcelain capacitors, dissipation factor is most revealing. The curve dramatically shows why it is possible to offer improved reliability under ten times more stringent test conditions.

Although the new S-1002 B combines the best features of the Darnell recommendations and the previous S-1002 specification, it still leaves room for further improvement.

Future Trends in Higher Reliability

The new S-1002 B program, as well as almost all other present day reliability programs, suffers from high cost, long lead time, and too much elapsed time between manufacturer and reliability test results. Although high cost and long lead time can sometimes be tolerated, the time lag between the production of components and the results of reliability testing is most dangerous since substandard lots can be produced for quite a period before the necessity for corrective action is indicated. In the case of a Darnell type reliability program, an occasional substandard lot may actually be utilized in equipment before a failure rate change has even became apparent.

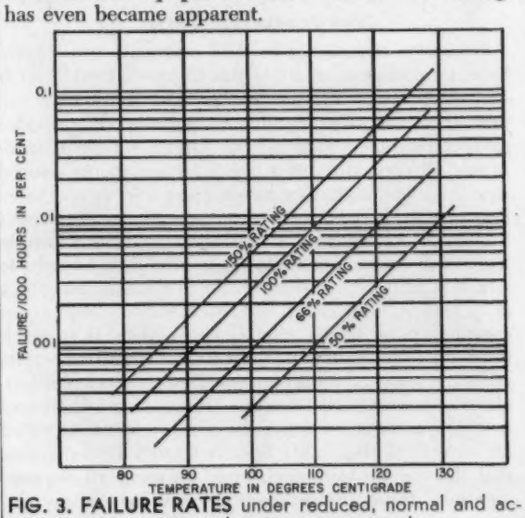


FIG. 3. **FAILURE RATES** under reduced, normal and accelerated life testing voltages are compared.

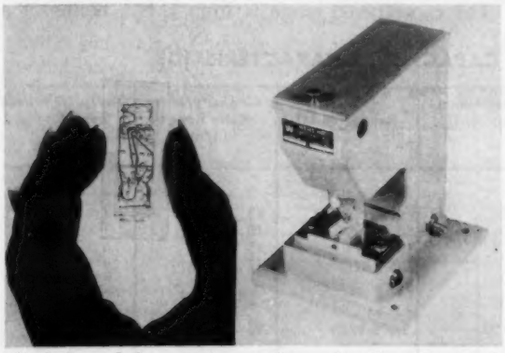
To overcome these weaknesses in present reliability specifications, an intensive investigation is being initiated on porcelain capacitors to provide test criteria which will make it possible to obtain complete reliability information on the basis of a test of 100 hours or less. This short test time will be made possible by using extremely high acceleration factors.

Although acceleration factors have been utilized previously in capacitor testing (Fig. 3) the development of acceleration factors of this magnitude will be novel. The voltage stresses needed to produce 100% failure at 125°C in 100 hours will be high in general; and the extra thick dielectrics utilized in "VY" capacitors to provide ultimate reliability will probably necessitate the design and fabrication of special life-test equipment. Assuming that statistically valid acceleration factors have previously been determined, it will be possible, by analysis of failure mode and failure distribution, to provide statistically valid reliability information from these tests. The program to develop the ultra-high acceleration factors needed to provide complete reliability data from a 100 hour test must necessarily be a prolonged, tedious one since it is imperative that all facets of failure distribution, failure mode and changes in failure mode with increasing voltage be thoroughly investigated.

Although the investment in time and money necessary to complete such a program will be high, it is anticipated that all component manufacturers will utilize this kind of program, bringing dividends in lower costs, more flexible deliveries, and—of paramount importance—more absolute assurance of reliability.

Mylar Film Punch

New tool for punching holes accurately in mylar films (shown on left) required to fabricate welded electronic modules and interconnecting matrices is solenoid operated by a foot-operated switch from 110v 60 cps. Light shining up through die hole in base illuminates the work and aids visual alignment between



die hole and the printing on the mylar film. Standard punch and die sets are .016", .028", .035", .040", .062" and .125" diameter. The punch housing is of cast aluminum with 5" x 6" base and stands 8" high. Punches are of ground, hardened steel. The new tool is a product of WEMS, Inc., 4807 West 118th Place, Hawthorne, Calif.

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MIL-S-901B reliability at 40 fathoms

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The rotary balanced armature, permanent magnet stabilization, full length armature bearing supported at both ends, contacts closer to the header, solid pole pieces and coil, and rugged can and terminal construction are the built-in qualities that provide superior shock immunity.

Standard catalog relays are rated at an operating shock of 50G for 11 MS. Units are available with operating shock ratings of any value up to the requirements of MIL-S-901B.

Time delay units can be designed to MIL-S-901B and to meet individual customer rating specifications.

Send your relay requirements for prompt engineering evaluation — today.

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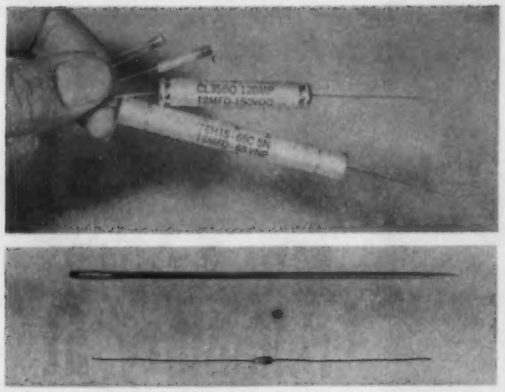

FIG. 1. **TANTALUM** Capacitor types (top to bottom): TE wire anode both leads at one end; TEW wire anode, axial; TEF foil and TEH foil. TS Capacitor, 3μf at 2 w vdc is shown with 3½" needle.

FIG. 2. **VERY HIGH CAPACITIES** in small volumes are afforded by new Tantalum Foil, Tansitor type CM capacitors.

by ROBERT RUSS
Tansitor Electronics, Inc.

Tantalum Capacitors

Electrolytic capacitors supply large values of capacitance within small physical dimensions. This dominant characteristic derives from their unique construction.

The necessary insulating medium, or dielectric, in the capacitor is an oxide film of the base metal formed electrolytically on the positive electrode or anode, hence the term "electrolytic" capacitor. The film may be very thin compared with other types of capacitor dielectrics, thus providing high capacitance for a small volume of electrode.

The oxide used in capacitor construction employing liquid electrolytes exhibits semi-conductor properties, acting as an insulator to dc in only one polarity direction. A non-polar electrolytic capacitor must have an oxide film deposited on both electrodes.

The oxides of all metals, however, do not exhibit the desirable semiconducting properties necessary for use in electrolytic capacitors. Aluminum, zirconium, tantalum, and columbium are a few metals which have the necessary attributes. Aluminum has for many years been used in electrolytic capacitors because of its so called "valve forming" properties, ease of fabrication, low cost and availability.

Increased military and commercial demands for higher and lower operating temperatures, higher volumetric efficiency, longer shelf life, high reliability, and inertness to generally destructive environmental conditions have been responsible for the rapid growth of tantalum capacitors. In a great many instances the high initial cost of tantalum itself is overshadowed by the superior characteristics of capacitors constructed with this metal. Tantalum was in fact so named because of its insolubility in most acids, which made its extraction from minerals "tantalizing". It is this chemical inertness which allows the use of tantalum capacitor electrodes in a wide variety of chemical electrolytes formerly not compatible with known methods of electrolytic capacitor construction.

A resume of the various types of tantalum capacitors (Fig. 1) may be helpful to the design and applications engineer. It is perhaps of further assistance to relate the various configurations to the basic concept of a capacitor, highlighting the features of each type construction.

To begin, a simple formula, $C = KA/t$, may be used to identify and define a capacitor; where C represents the capacitance, A the active dielectric area, K a constant which includes the dielectric constant of the insulating material and t, the thickness of separation of two conducting parallel plates. Thus, two conducting plates separated by an insulator constitute a capacitor whose capacitance increases in direct ratio to the dielectric constant and the area of the plates or in inverse ratio to the separation of the plates.

Three Types of Tantalum Capacitors

At the present state of development the three basic types of construction employed in the manufacture of tantalum capacitors include (1) foil, (2) sintered anode and (3) wire types. Several configurations of any one of the basic styles may be obtained, each having its own particular—and often greatly different —characteristics as illustrated in Table 1.

1. Tantalum Foil Capacitors

This type construction employs tantalum foil—usually 0.0005" thick—as the capacitor electrodes, tantalum pentoxide as the insulating film and a conducting electrolyte. The foils may be plain or of the etched variety. The latter have greater surface area for a given projected area, hence yield more capacitance.

The additional cost of manufacture of etched foil types sometimes make a plain foil construction in a larger case more economical to the user where space is not at a premium. Plain foil types, in general, have superior temperature stability over etched foil in the same voltage rating. However, temperature stability characteristics are dependent to a considerable degree on the electrolyte system used.

Tantalum foil capacitors built to MIL-C-3965B are available in −55°C to +85°C and −55° to +125°C operating temperature ranges.

The capacitance range is from a few tenths of a

TABLE 1. COMPARISON OF TANTALUM CAPACITOR CHARACTERISTICS

Type of Construction	Operating Temperature Range °C	Voltage Range vdc	Capacitance Range (μf)	Volume Range (cu-in)	Capacity/Mass Ratio Range μf/gm	Capacity/Volume Ratio Range μf/in³
Ta Foil						
TEF	−55 to +85	3-150	.25-580	.019-.432	18 - 28	13 - 1350
TH	−55 to +125	3-150	.15-580	.021-.451	.15 - 39.5	7 - 1280
HV	−55 to +125	200-300	13-35	.021-1.72	.13 - 1	6 - 20
TES	−55 to +85 intermittent operation to +125	6-150	1-600	.05-.157	.27 - 83.3	20 - 3800
CM	−55 to +125	3-300	19-310,000	3.875-47.2	.05 - 66	5 - 6500
Sintered Anode						
W (Wet Electrolyte)	−55 to +85	6-125	1.7-560	.012-.12	1.2 - 83.5	140 - 4650
TS (Mil. Solid Electrolyte)	−80 to +125	6-35	.0047-330	.0031-.068	.01 - 57	1.5 - 4850
S (Comm. Solid Electrolyte)	−55 to +85	2-15	.01-20	.0005-.0026	.15 - 87	20 - 7700
Wire						
TE	−30 to 71	1-30	.01-30	.00066-.010	.125- 38.5	15 3000

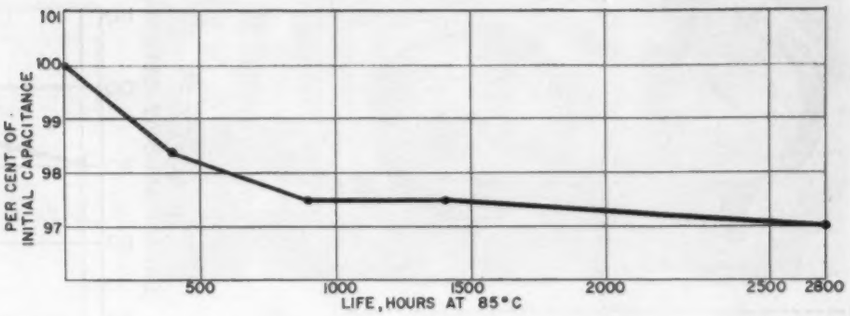

FIG. 4. CAPACITANCE-LIFE curve for type W sintered tantalum slug, liquid electrolyte capacitors. Initial capacity (at 25°C is plotted vs life in hours.

— Electrolytics with High Volumetric Efficiency and Reliability

microfarad to several hundred microfarads in a single case, depending on the voltage rating.

Recent developments in a presently non-standard military design have yielded a new and larger version (Type CM) in the rectangular foil construction. This construction (Fig. 2) offers previously unavailable magnitudes of capacitance and voltage ratings in a single package. Case sizes range to 3½" x 3½" x 3¾" in size with capacitance upwards of 300,000 microfarads available in lower voltage ratings. Dual section units are also available. This type of capacitor is well adapted to custom manufacturing.

Polar Units vs A-C Units

Foil type capacitors may be constructed as "polar", "non-polar", or what might be called semi-polar units. Since both capacitor electrodes are of tantalum, it is possible to "form" an oxide film on either or both electrodes. Therefore, the amount of "formation" on each electrode will determine the voltage stress the capacitor will withstand in each polarity direction.

When two capacitor electrodes have the same oxide film thickness they will withstand equal dc voltage application in either direction. One oxide film acts as the insulating medium in one polarity direction, the other equally thick film acts as the insulator in the reverse polarity direction. This feature reduces the capacitance available in a given capacitor case size because the thickness of dielectric is essentially increased, yielding lower capacitance per unit area.

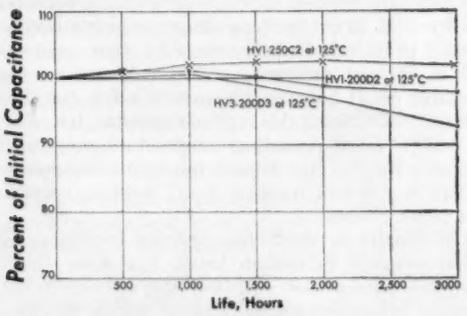

FIG. 3. CAPACITANCE-LIFE characteristics for three type HV (125°C rated) tantalum foil capacitors. Percent of initial capacity (at 25°C) is plotted vs life in hours.

The term non-polar is sometimes misinterpreted to mean that the voltage ratings apply to ac, which is not necessarily true. The impedance a capacitor exhibits to ac is related to the value of capacitance and frequency of the applied voltage. A non-polar capacitor may allow only microamperes of current to "leak" through when subjected to a dc potential. However, the same capacitor when subjected to ac may allow several amperes of current to flow. Where the heating effect of the direct current may be negligible, that of the alternating current may be considerable.

A capacitor's ac impedance is expressed as $Z = (x^2_c + R^2)^{½}$ where X_c = the capacitive reactance $= 1/(2\pi fc)$; where f = frequency in cps, c = capacitance in farads, and R = the equivalent series resistance of the capacitor. Thus the ac current flowing through a capacitor may be $I_{ac} = E/Z$ where E = the applied rms voltage and Z the capacitor impedance at the frequency. For example, a 100μf capacitor presenting 13.26 ohms impedance (neglecting the equivalent series resistance) at 120 cps to an ac potential of 100 volts 120 cps would result in 7.54 ampere flowing through the capacitor. This is in contrast to the normal micro-ampere range leakage current encountered in dc applications.

It is apparent that the heat dissipation in an ac application may become a limiting factor due to the larger current which may flow. In general, it is wise to consult the manufacturer in applications where a non-polar tantalum capacitor will be subjected to ac voltage.

Resistance to Environmental Stresses

Tantalum foil capacitors withstand severe environmental conditions with little or no degradation. Life testing to the MIL-C-3965B specification at full rated voltage and maximum operating temperature allows a maximum decrease of 25% from the original capacitance. However, many ratings may perform more than 15,000 hours under these conditions without exceeding the allowable capacitance change. Fig. 3 shows capacitance-life curves for three typical type HV tantalum foil capacitors.

The simple construction of a foil type capacitor makes it shock-and-vibration-resistant. Larger case sizes, however, do make it necessary to mount the capacitors by their bodies to insure safe operation under test conditions of up to 30 G at 10 to 2000 cps vibration and up to 15 G acceleration. Shock tests of 750 G's for a 0.4 msec pulse and 250 G's for a pulse duration of 15 msec have been successfully performed. A near hermetic seal helps make this construction practically impervious to moisture resistance and corrosion type testing.

The most common type of operational failure to be expected in Ta foil capacitors is slow degradation brought about by the loss of electrolyte through the end seals. This loss normally takes place very slowly and in a vapor phase such that the external appearance of the capacitor may not noticably change. It will be evidenced by a gradual loss of capacitance, increase in power factor and decrease in leakage current.

2. Sintered Anode Type Tantalum Capacitors

As previously mentioned, sintered anode types of construction may be divided into (a) "wet" and (b) "solid" configurations. Each employs a tantalum anode made by pressing tantalum powder into a compact, usually cylindrical, shape; and sintering at a high temperature under high vacuum. The resultant porous anode is of high purity and yields high capacitance per unit volume. Its sponge-like construction allows for penetration of the electrolyte system so that the surface area extends through nearly the entire mass, contributing to the capacity.

Wet Electrolyte Types

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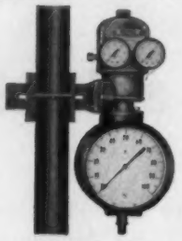

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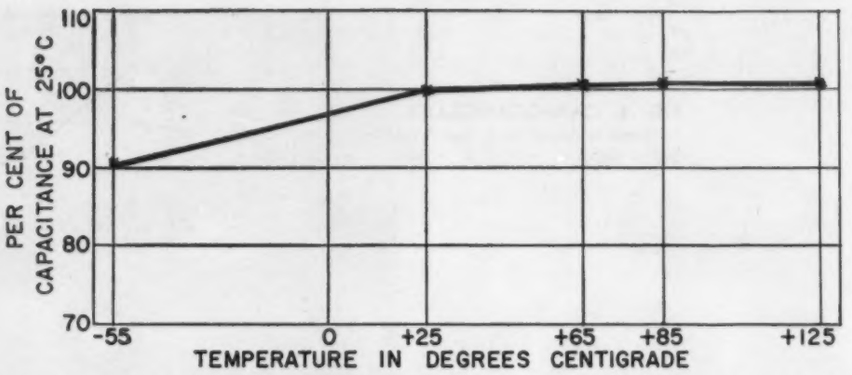

FIG. 5. CAPACITANCE VS TEMPERATURE for type S solid electrolyte sintered tantalum capacitor. Percent of capacitance at 25°C is plotted vs temperature over the range of —55° to 125°C.

the pioneer components in the tantalum electrolytic industry. Initially, the use of a porous mass anode and a highly conducting electrolyte opened a new field in which much higher capacitances per unit of volume, extremely low leakage currents and long operating life for electrolytic capacitors, could be obtained. The use of sintered tantalum powder, which is the first end product in the reduction of tantalum ore, yields a basic anode material of the highest possible purity. A highly conducting electrolyte, usually a strong acid, helps maintain desirable temperature characteristics and a low power factor. The acid electrolyte has, however, limited the operating voltage range to 125 v dc. Attempts to increase the voltage range are hampered by the requirement that the electrolyte system cannot break down internally under voltage stress while maintaining the high conductivity necessary for low power factor and good temperature stability.

The physical configuration of the sintered anode limits its use to polar capacitors only. Long electrolyte paths contribute to the equivalent series resistance of a capacitor, thereby giving rise to high power factor. Thus, two cylindrically formed anodes immersed in a highly conducting electrolyte would yield a power factor deemed unusable by most military requirements.

Operational failure of "wet slug" type capacitors may be expected to be of the same nature as that of the foil type in that a gradual degradation of the capacitor is brought about by a loss of electrolyte in the vapor phase through the end seal.

In the event of a defective seal, the loss of the strong acid electrolyte may be more damaging to surrounding components than the neutral electrolytes used in foil constructions. The "wet slug", however, usually employs only one end seal, due to the fact that the normal case is a metal cup. Thus, the cross sectional area of end seal through which electrolyte may escape is reduced to a minimum. Capacitance-life of a typical type W sintered anode tantalum capacitor is shown in Fig. 4.

The ability of this type of capacitor to withstand severe environmental conditions is also in the same general order of magnitude of shock, vibration, etc. as foil constructions.

Solid Electrolyte Types

"Solid" electrolyte capacitors employ a solid-state electrolyte. As in the wet sintered anode construction, certain limitations are effected as compared to foil construction while improved characteristics are realized in other areas.

A solid tantalum capacitor using MnO_2 electrolyte may be operated over a wide temperature range without encountering pronounced changes in conductivity. This means a more stable equivalent series resistance and improved power factor characteristics. Capacitance change with temperature is also lessened over other constructions (Fig. 5). The use of a solid system prevents objectionable escape of electrolyte as a liquid and greatly extends the life of the capacitor. Improved shelf life characteristics allow storage in ambients from —80°C to +125°C for units of this type. A loss of less than 10% of room temperature capacitance at —55°C is normal, as is a dissipation factor of less than eight per cent under the same low temperature condition.

A maximum working voltage of 35 volts dc has been one seriously limiting characteristics of the solid type construction. Recently the voltage range has been expanded to include 50 volt ratings by some companies and in at least one instance, 75 volt ratings. Considerable effort has also been extended in the direction of miniaturizing this type of capacitor. Its —55°C to +85°C rated operating temperature range make available for the first time a miniature tantalum capacitor capable of meeting many military specification requirements.

The manner in which this capacitor sometimes fails causes concern in certain areas. For some time it has been known that sudden, unexplained, catastrophic failures occasionally occur during the life of solid electrolyte capacitors. This failure is greatly abetted when the capacitor is used in a circuit having low impedance and a power source capable of delivering high current. Apparently, the high current can

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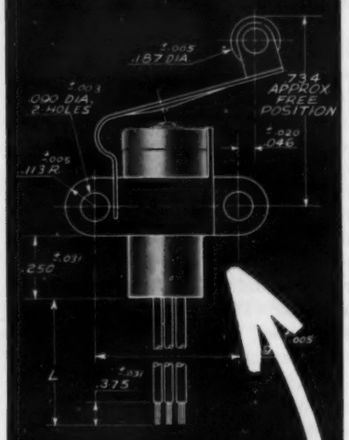

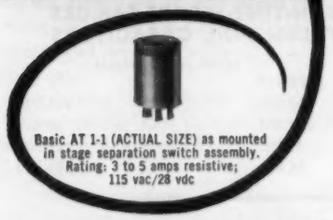

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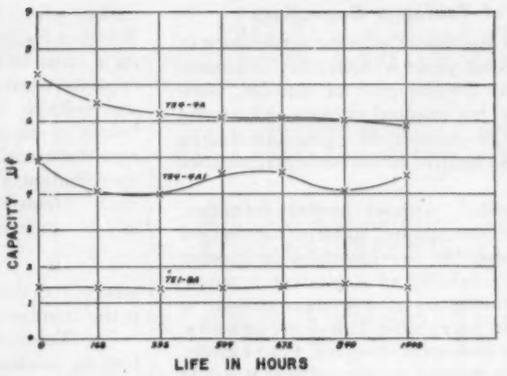

FIG. 6. CAPACITANCE-LIFE tests for three sizes of tantalum wire anode capacitors, type TE, show how capacity of each varies with hours at 100°F in 95% relative humidity conditions.

cause catastrophic failure of the capacitor if only a momentary dielectric breakdown occurs.

Because of such unpredictable sudden breakdowns it has been recommended that wet type tantalum constructions, immune to this type of failure, be used in low impedance applications requiring extremely high reliability. However, extremely good reliability is attained with solid tantalum capacitors in applications where the circuit impedance is high, which virtually eliminates the catastrophic breakdown. Also continual improvements in this newer type capacitor indicate that low impedance failure eventually may be largely eliminated by better manufacturing technology.

3. Wire Types

The miniature tantalum wire type capacitor, because the relatively small amount of tantalum used in its manufacture does not impose a high initial raw materials cost, is attractive to commercial as well as military applications.

Retaining most of the properties of tantalum capacitors built for rugged military use, the wire capacitor also features extremely small size with a variety of lead configurations available for versatile mounting. It is readily adapted to printed circuit boards and is utilized to a great extent by the hearing aid industry. The normal operating temperature range is −55°C to +65°C with some types rated up to +71C. Normal voltage ratings are in the 1-15 volt range and capacitance up to 40μf at 3 v may be expected in a nominal .138″ O.D. by .375″ length unit. Presently, units are available having as little as an .075″ diameter by .150″ length, yet with ratings of as much as 7 volt-mfds.

Since these capacitors do employ wet electrolytes and are extremely small in size, somewhat poorer temperature stability characteristics must be expected.

Also, the nature of the design and construction dictate larger capacitance tolerances with up to a +200% tolerance being quite normal. Typical capacity-life test curve for Type TE capacitors is shown in Fig. 6.

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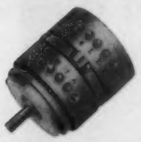

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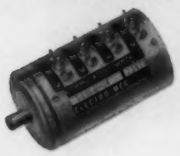

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Reliability of Tantalum Capacitors

A term which has become of extreme importance to engineers within recent years is "reliability". Concentrated efforts in the development of missiles, computers, satellites, etc. has resulted in increased interest in the probability of component parts functioning properly, as required for the satisfactory performance of equipment.

The term "reliability", without further definition, becomes nebulous. The almost infinite number of particular applications for any electrical component make defining the reliability of a product a monumental task. When numerous parameters contribute to the definition of an acceptable tantalum capacitor, the subject becomes even more complex. For example, a light bulb might be termed as acceptable if it would light. A tantalum capacitor, on the other hand, must meet capacitance tolerances, leakage current and power factor limits under each of several environmental conditions. Without definition of the particular conditions, the reliability of the capacitor becomes completely obscure.

Since normal operation of tantalum capacitors might require years to produce defects contributable to the condition of use; accelerated life testing under severe temperature environment and voltage application conditions is most often used in attempting to define the reliability of tantalum capacitors. Again, it is most important to understand that what might be extremely reliable in one application, may be unreliable in another. This is dependent entirely upon the required function of the part to contribute to overall successful operation.

Mean-Time-Between-Failure Rate

One statistic of reliability which is often employed is Mean-Time-Between-Failure (MTBF). Tansitor engineers, for example, have accumulated life test data subject to the Mil-C-3965B and Tansitor Specifications which has been correlated to the Mean-Time-Between-Failure rate. This data has been collected on a cross section of random samples of production capacitors tested at their maximum rated temperature and voltage. Short or open circuited capacitors, or values of capacitance, power factor or leakage current that exceeded the requirements of the applicable specification, constituted failures, for purposes of this study. Mean-Time-Between-Failure has been defined as

$$M\ T\ B\ F = T/n$$

where T is the total accumulated test unit hours and n the number of failures observed.

For Tansitor TEF (85°C) tantalum foil capacitors an accumulated test time of 705,113 unit hours representing 268 capacitors was used, while similar data on Tansitor TES (85°) foil capacitors for an accumulated time of 366,000 unit hours was used. A minimum of 2000 hours test time was considered in order to comply with Mil-C-3965B, and additional test time was also accumulated. Calculations were made separately for intervals of 0-2000, 0-3000, 0-4000 and 0-5000 hours, with results as shown in Table 2.

It can be seen from this data that impressive figures of reliability are available. The tantalum capacitor is basically reliable when used in proper applications. It should be realized that maximum values for all characteristics are not attainable in a single capacitor; but that a maximum in one parameter is usually attainable only at the expense of another.

TABLE 2. MEAN-TIME-BEFORE-FAILURE RATE—TANTALUM FOIL CAPACITORS

Test Interval in hours	MTBF in Unit-Hours TYPE TEF	TYPE TES
2000	352,556	366,000
3000	244,357	58,666
4000	41,087	28,000
5000	35,806	25,900

Applications for Electrically-Variable Inductors

The property of the saturable-core reactor in changing the inductance of one coil by passing dc current through another is also the basis of operation of the variable inductor (Fig. 1). Instead of operating as a power-controlling device, the variable inductor generally controls the resonant frequency of a circuit for which it, together with a suitable tuning capacitance, constitutes the frequence-determining element.

Since the range of Vari-L units is greatly in excess of that required, often only a portion of the curve is of interest to the engineer. Approximately half of the average curve is quite straight, so most applications are taken care of by this inherent linearity of the design. Equipment requiring high linearity should make use of inductors for the lowest applicable frequency, possibly at the sacrifice of Q. Also, considerable latitude is possible through proper shaping of the core which we often em-

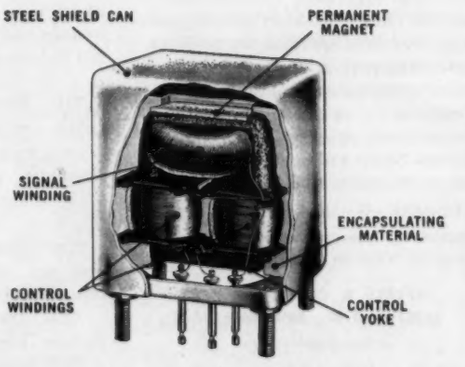

FIG. 1. TF TYPE VARIABLE INDUCTOR, Cut-away view.

ploy to fill linearity specifications of the customer. In many instances a permanent magnet is utilized to pre-

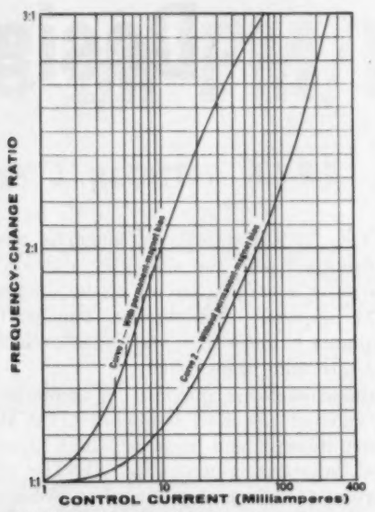

FIG. 2. CURRENT-FREQUENCY characteristics: Curve 1, with permanent magnet bias; curve 2, without permanent magnet bias.

saturate the core over part of its range, thus placing the O-current operating point at the beginning of the more desirable portion of the curve (Fig. 2).

Typical production applications are listed below. Some of the firms whose equipment is described have been using the same basic models consistently for over eight years, and we take pride in this record of trouble-free service:

Ultrasonic instruments for non-destructive thickness testing use the Vari-L to search out thickness resonances, which are displayed on an oscilloscope, calibrated directly in thickness.

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Improved Types
For low noise superheterodyne mixer performance
• Replace 1N21 series

Fixed Base Types		Matched Pair		Reversible Polarity Types	Calc Overall Rec'r Noise Figure N 1.5db (db)	Burnout Rating (ergs)
Forward Polarity	Reversed Polarity	Forward Pair	Forward & Reversed			
MA-449B	MA-449BR	MA-449BM	MA-449BMR	MA-459B	10.3	5.0
MA-449C	MA-449CR	MA-449CM	MA-449CMR	MA-459C	8.3	5.0
MA-449D	MA-449DR	MA-449DM	MA-449DMR	MA-459D	7.3	5.0
MA-449E	MA-449ER	MA-449EM	MA-449EMR	1N21WE	7.0	5.0
MA-449F	MA-449FR	MA-449FM	MA-449FMR	MA-459F	6.0	5.0

Higher Burnout Types
For use in pulse radars or other receivers exposed to high RF radiation fields
• Interchangeable with 1N21 series

MA-4127	MA-4127R	MA-4127M	MA-4127MR	MA-4132	8.3	10

Lower Noise Types
For best signal-to-noise performance in low frequency IF doppler systems.

MA-4126 MA-4126A	MA-4126R MA-4126AR	MA-4126M MA-4126AM	MA-4126MR MA-4126AMR	MA-4131 MA-4131A	— —	2.0 2.0

4,000 Mc — 10,000 Mc

Improved Types
For low noise superheterodyne mixer performance.
• Replace 1N23 series

MA-451B	MA-451BR	MA-451BM	MA-451BMR	MA-458B	11.4	2.0
MA-451C	MA-451CR	MA-451CM	MA-451CMR	MA-458C	9.8	2.0
MA-451D	MA-451DR	MA-451DM	MA-451DMR	MA-458D	8.2	2.0
MA-451E	MA-451ER	MA-451EM	MA-451EMR	IN23WE	7.5	2.0
MA-451F	MA-451FR	MA-451FM	MA-451FMR	MA-458F	7.0	2.0

Higher Burnout Types
For use in pulse radars or other receivers exposed to high RF radiation fields
• Interchangeable with 1N23 series

MA-4133	MA-4133R	MA-4133M	MA-4133MR	MA-4134	9.8	5.0

Lower Noise Types
For best signal-to-noise performance in low frequency IF doppler systems.

MA-4125 MA-4125A	MA-4125R MA-4125AR	MA-4125M MA-4125AM	MA-4125MR MA-4125AMR	MA-4130 MA-4130A	— —	2.0 2.0

10,000 Mc — 18,000 Mc
COAXIAL CASE

Improved Types
For low noise superheterodyne mixer performance
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MA-443 MA-443A MA-443B	MA-443R MA-443AR MA-443BR	MA-443M MA-443AM MA-443BM	MA-443MR MA-443AMR MA-443BMR	— — —	— 9.8 8.8	0.6 0.6 0.6
MA-445 MA-445A MA-445B	MA-445R MA-445AR MA-445BR	MA-445M MA-445AM MA-445BM	MA-445MR MA-445AMR MA-445BMR	— — —	— 9.8 8.8	1.0 1.0 1.0

Lower Noise Types
For best signal-to-noise performance in low frequency IF doppler systems.

MA-4124 MA-4124A	MA-4124R MA-4124AR	MA-4124M MA-4124AM	MA-4124MR MA-4124AMR	— —	— —	0.6 0.6

SILICON VIDEO DIODES
1 Mc — 10,000 Mc

Improved Types For high tangential signal-to-noise sensitivity in simplified beacon receivers, test equipment and other uses.
• Replace MA-408 series CARTRIDGE CASE

Fixed Base Types		Reversible Polarity	Burnout (ergs)
Forward Polarity	Reversed Polarity		
MA-452 MA-452A MA-452B	MA-452R MA-452AR MA-452BR	MA-461 MA-461A MA-461B	1.0 1.0 1.0

Higher Burnout Wide Dynamic Range Types
For use in video receivers exposed to high RF radiation fields.
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MA-4128	MA-4128R	MA-4129	5.0

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Design

LONG TERM stability of magnetic elements is combined with the simplicity and low cost of a pulse averaging circuit in the unique Airpax FM/FM frequency discriminator. The heart of this discriminator is the Airpax Magmeter®, which is basically a saturating transformer.

A driving amplifier provides an amplitude-limited square wave of subcarrier frequency to the Magmeter frequency detector and presents a high input impedance to the signal source (Fig. 1). The saturating transformer (Magmeter) produces an average output voltage linearly proportional to this input frequency. This average output, at subcarrier band center, is nulled out by a stable reference voltage. Frequency deviations about this center frequency provide corresponding positive and negative voltage deviations about null. The deviation and center frequency of operation are a function of the reference voltage level and saturating transformer turns.

The saturating transformer performs its frequency detection function by acting as a nearly perfect volt-second limiter. Its operation depends on the sharply rectangular nature of the nickel-iron alloy transformer core material used. This is explained as follows:

The well known Faraday transformer equation gives the instantaneous induced secondary voltage as

$$e = -N\frac{d\phi}{dt}10^{-8}\ \text{volts}$$

where N represents the number of winding turns and $d\phi/dt$ the rate of change of flux linkages. The integrated value of this expression represents the volt-second area supported for a given flux excursion

$$\int_{t1}^{t2} e\,dt = -10^{-8}N\int_{-\phi\,max}^{+\phi\,max} d\phi$$

where $t_2 - t_1$ represents the time until saturation occurs (90° at bandcenter). ϕ_{max} is defined as $2B_{max}$ (saturation flux density) xA_c. A_c is the effective toroidal core cross section. ($-B_{max}$ is assumed to equal $+B_{max}$.) For a given transformer, the turns are fixed and flux limits well defined, so that the output pulses are of constant volt-second area given by

$$e(t_2 - t_1) = -N2\phi\,max = \text{a constant}$$

Thus, a method is obtained to standardize pulses. The saturating transformer's average output voltage is proportional only to input frequency, i.e., the "number" of the input pulses per unit time.

# of an FM/FM Telemetry Discriminator

ROBERT J. RECHTER, B.S.E.E. Airpax Electronics Incorporated, Ft. Lauderdale, Florida

The basic principle of operation as stated above is quite straightforward; however, the minimization of practical second-order effects is considerably more sophisticated. These include minimization of driving voltage error, non-linearities due to oscillatory phenomena in the saturating transformer, temperature coefficients, and waveform, loading and filtering errors.

Minimization of Second-Order Effects

Considerations in the saturating transformer design include particular *core material characteristics;* for instance, a high squareness ratio is desirable. A highly rectangular hysteresis loop will produce less energy available for oscillation after transformer saturation. A low value of core loss is desirable from the point of reducing primary magnetizing current. Thin tape is desirable because of eddy current minimization. The winding pattern of primary and secondary windings is important, since leakage inductance must be minimized.

In general, it can be shown that the condition for minimum energy stored in the transformer secondary is that the load impedance $R = \sqrt{L_L/C}$ or that the secondary L and C simply be reduced to a minimum. (L_L is leakage inductance plus saturated secondary inductance). The Magmeter saturating transformer is generally designed with this in mind.

Second order effects due to *driving signal voltage amplitude* and *waveform variations* are eliminated by particular attention to the nature of the driving amplifier circuitry. The effect due to voltage level occurs mainly because the saturation flux density limits of the core hysteresis curve have a very slight slope. These very slight volt-second non-linearities are eliminated by converting the drive signal to an amplitude-limited square-wave.

This driving amplifier circuitry (Fig. 2) takes the form of a low-noise emitter-follower input stage of approximately 30 v peak-to-peak dynamic range, optionally followed by a bandpass filter, 4 stages of amplification with diode clipping, an emitter-coupled multi-vibrator (Schmitt trigger), its following phase inverter, and final push-pull power amplifier. The input stage uses a composite silicon transistor with high collector voltage rating for the wide dynamic signal range and low output impedance. Diode limiting in the following amplifier stages, and high frequency switching transistors in the Schmitt trigger provide a square wave of relatively constant amplitude, fast rise and fall times over a practical frequency range of less than 400 cps to 200 kc. The half-period time balance of the square-wave is good over this frequency range, providing maximum Magmeter linearity.

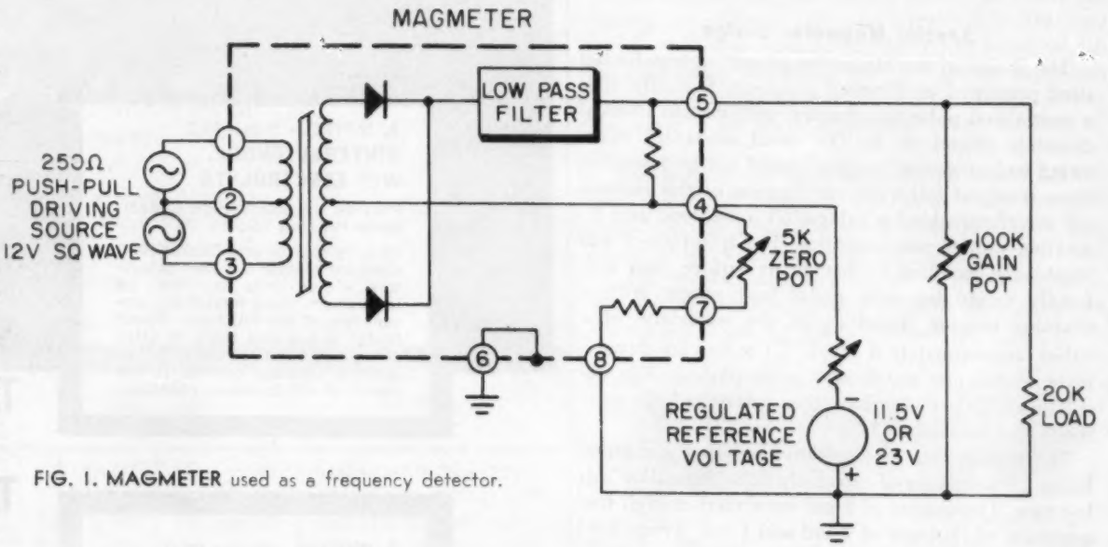


FIG. 1. MAGMETER used as a frequency detector.

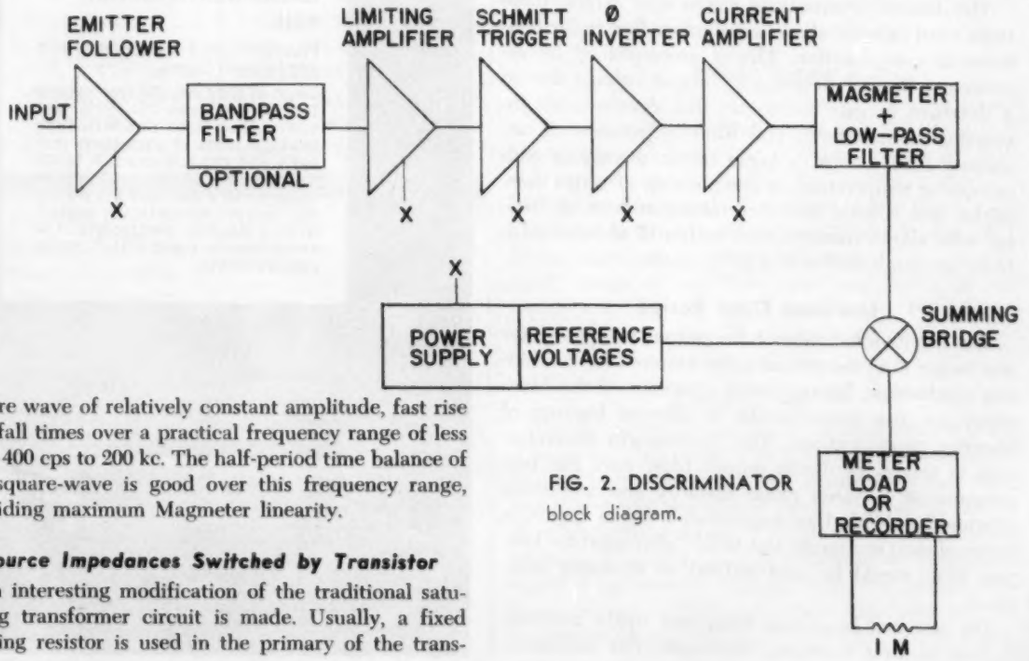


FIG. 2. DISCRIMINATOR block diagram.

Source Impedances Switched by Transistor

An interesting modification of the traditional saturating transformer circuit is made. Usually, a fixed limiting resistor is used in the primary of the trans-

former to limit primary current after saturation. However, it was found that maximum linearity of the saturating transformer occurs within a certain range of saturation current, or magnetizing intensity. Because minimum source resistance is demanded in the pre-saturation interval, a fixed resistor would at best be a compromise. Instead, a transistor switch is used to switch in one value of source driving resistance *before* transformer saturation, and another value *after* saturation. In this way, driving and saturation source impedances are independently controlled.

Special Magmeter Design

The design of the Magmeter saturating transformer itself presented challenging problems. Basically, it is a specialized pulse transformer, with certain unusual demands placed on it. The usual secondary backswing and excessive "ringing" could not be tolerated, since resultant full-wave rectification of this secondary waveform added or subtracted volt-second area . . . creating output non-linearities. The transformer was impedance matched by having its surface area artificially varied by extra mylar tape wraps, with a shunting resistor placed across the secondary, of a value (approximately $R = \sqrt{L/C}$) so that an approximate impedance match was accomplished. The resultant secondary waveform then exhibited little overshoot and oscillation.

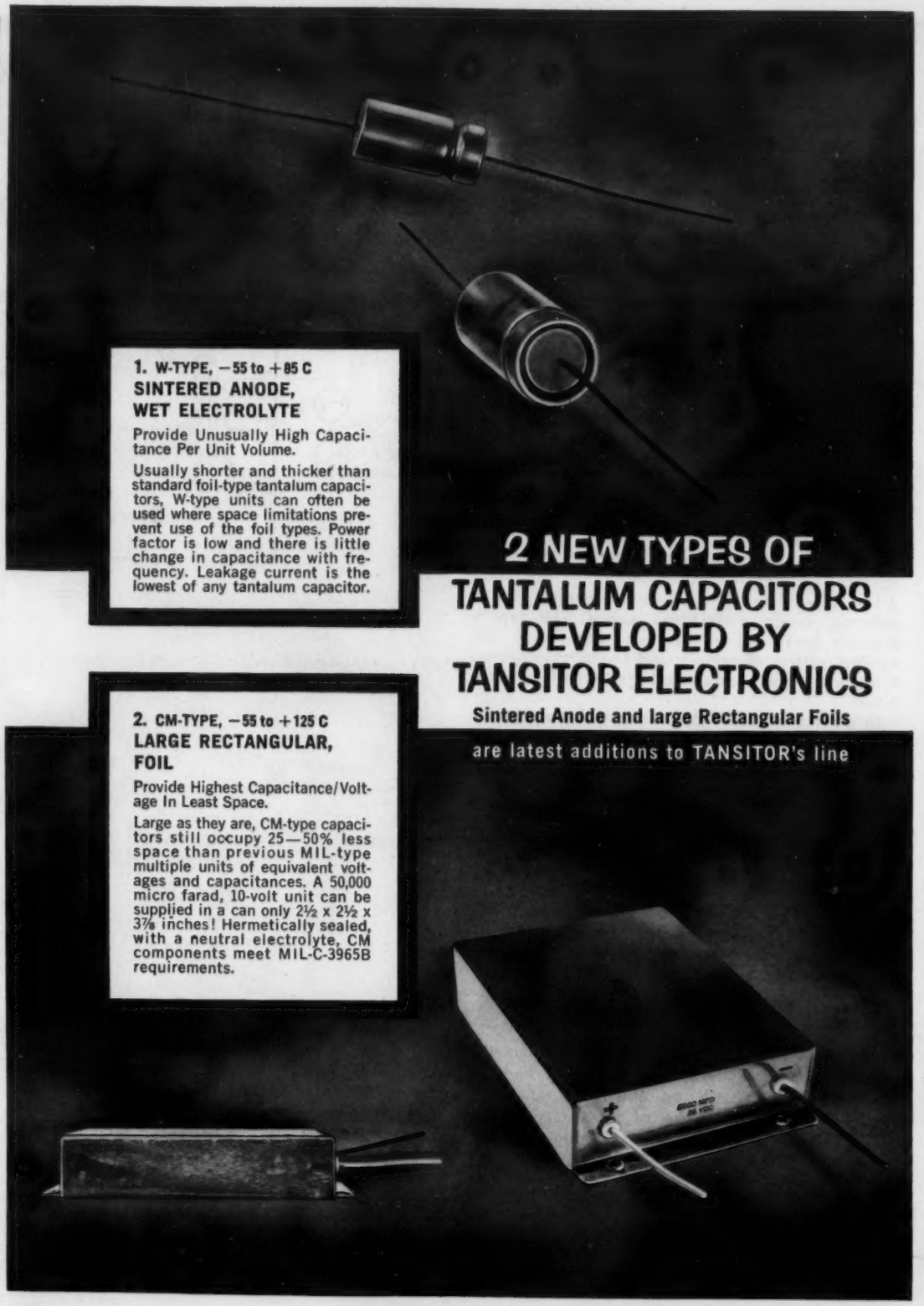
The transformer core construction used a ceramic bobbin, with wraps of extremely thin "Permalloy" alloy tape. Thicknesses of ¼ mil were used at high frequencies, while tapes of ½ mil and 1 mil "Permalloy" were used at lower frequencies.

The limited temperature range over which these units must operate allows satisfactory first order temperature compensation. This is accomplished by assuming a "linear" decrease in output voltage due to a decrease in core maximum flux density with increasing temperature. The filter inductance dc resistance is, of course, a linear factor, increasing with increasing temperature. A combination of series thermistor and voltage reference mixing resistor of "Balco" wire allows compensation within 1% of bandwidth to be accomplished over a 20°C range.

Low-pass Filter Design

The input inductance of the output low-pass filter was larger than the critical value required for continuous conduction. No unilateral operation of the Magmeter rectifier diodes could be allowed because of linearity considerations. The Butterworth characteristic in this 4- or 6-pole output filter gave the best compromise between phase linearity and amplitude attenuation. With time-commutated signal inputs, a linear phase (maximally flat delay) characteristic low-pass filter would be used instead, to minimize overshoot.

The optional band-pass filter was made available in four transfer functions, maximally flat amplitude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Foil, axial leads	TEF	—55 to +85	3 to 150	0.25 to 440	0.5 to 580	0.187 x 0.687 to 0.375 x 2.75
Foil, single ended	TES	—55 to +85	6 to 150	1 to 90	1.8 to 600	0.312 x 0.650 to 0.375 x 1.0
Foil, axial leads	TEH	—55 to +125	3 to 100	0.25 to 350	0.5 to 150	0.187 x 1.0 to 0.375 x 3.25
Foil, axial leads	TH	—55 to +125	3 to 150	0.15 to 350	0.28 to 580	0.187 x 0.75 to 0.375 x 2.875
Foil, axial leads	HV	—55 to +125	200 to 300	0.13 to 35	None	0.187 x 0.75 to 0.531 x 2.875
Foil, rectangular	CM	—55 to +125	Up to 300	Up to 1,000,000		1 x 1 x 3⅞ to 4 x 6 x 6½
Wire anode	TE	—30 to +65	1 to 4	0.01 to 1	1 to 16	0.075 x 0.150 to 0.103 x 0.313
Wire anode	TEW	—55 to +71	2 to 30	1 to 4	4 to 60	0.138 x 0.219 to 0.138 x 1.0
Sintered, solid	S	—80 to +125	6 to 35	0.0047 to 60		0.125 x 0.250 to 0.341 x 0.750
Sintered, solid	TS	—80 to +125	1 to 15	0.0047 to 40		0.065 x 0.150 to 0.150 x 0.330
Sintered, wet	W	—55 to +85	6 to 125	1.7 to 560		0.187 x 0.453 to 0.375 x 0.766

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(Butterworth), maximally flat delay and 1 and 3 db ripple Chebyshev functions. These were voltage-driven 3-pole, 4-pole or 5-pole configurations. This voltage source was the output resistance of the composite input emitter follower stage. The amplitude characteristic of the filter had to have sufficient attenuation at adjacent band-edge to minimize interfering modulation effects of the difference frequency. Attenuations of 30 to 40 db were typical, depending on gain function and its order.

The resultant Butterworth (constant amplitude) and Chebyshev (equal ripple) band-pass filters exhibited good phase shift characteristics in the pass band, and the maximally flat delay was linear within the measuring resolution for the narrow expansion channels. Adjacent channel band-edge attenuation for the 3-pole, 3 db ripple Chebyshev filter ran 35 to 40 db.

The Butterworth low-pass exhibited over-shoot for step changes as expected. The linear phase low-pass exhibited negligible over-shoot with this input. The linear phase amplitude response is bell-shaped, and approaches the Gaussian curve for an increasing number of poles. Ordinary pole-zero methods of synthesis were used in passive Cauer realizations.

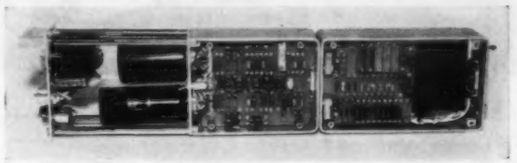

FIG. 3. **COMPACT** single-channel discriminator. Eighteen of these Compact discriminators fit in a standard 19" rack 8.75" high.

Power Supply

The power supply also has heavy demands placed on it. In one discriminator model (Fig. 3), the size of the transformer had to be held to a minimum. With the core volume available, the heating problem is greatest at 50 cps and 125 vac power line input. Class H materials were used to accommodate the 25°C temperature rise in the transformer. The large dynamic range of the input stage required a 40 volt supply carefully regulated to minimize ripple since the total driving amplifier gain was high.

Output Amplifier

The discriminator was designed to drive low-power voltage-operated loads. The lowest impedance of the unaided output load was 20 K ohms (the panel-meter load). If lower impedance loads, such as galvanometers, were to be driven, a dc output amplifier would be used. This is a chopper-stabilized or differential amplifier for required linearity and drift performance. Commercially available solid-state units were utilized. Output power of ±100 ma at ±10 volts was available.

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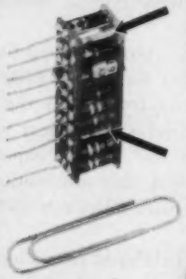

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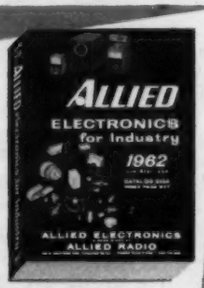

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Discriminator Characteristics

This design effort has produced a discriminator with a 60 db dynamic input range, from 10-mv to 10-v rms, without manual gain change. The peak-to-peak linear input range is 30-v, which is adequate for most 18 channel composite input signals. Input impedance at all points, in and beyond the channel passband, is at least 51 K.

Static linearity of the Magmeter frequency detectors is ±0.15% of bandwidth (2-v bandwidth) or better. This is a figure which includes normal production limits; actually a linearity of 0.05% of bandwidth is more generally experienced. Linearities of ±0.2% could be maintained even with the amplifier circuitry. Typical harmonic distortion does not exceed 0.8% with a modulation index of 5.0. The output range is ±1v dc into a 20K panel meter (without amplifier). The discriminator output impedance, without an output dc amplifier is 4 K. Output noise and ripple does not exceed 3 mv rms or 0.15% of bandwidth. The drift stability is better than 0.25% of bandwidth, after an initial 30 minute warm-up, over periods as long as 12 hours. The thermal time constant of each Magmeter module is about 5 minutes to 90% of final drift. A 5-minute waiting period before calibrating each channel reduces the zero drift error to less than 0.1% of bandwidth.

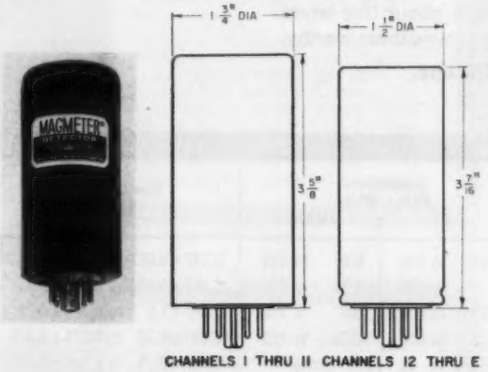

FIG. 4. MAGMETER plug-in module and dimensioned outlines.

The intelligence bandwidth of the finalized discriminator is approximately the required IRIG bandwidths. The −3 db time-commutated IRIG bandwidths of 4 times the recommended sampling rates, are also made available in linear phase functions. The standard IRIG center frequencies and deviations are covered. Non-standard ranges can easily be obtained by simply changing the reference and Magmeter output voltages. This indicates that all non-standard frequency and deviations are accommodated entirely in the plug-in modules (Fig. 4).

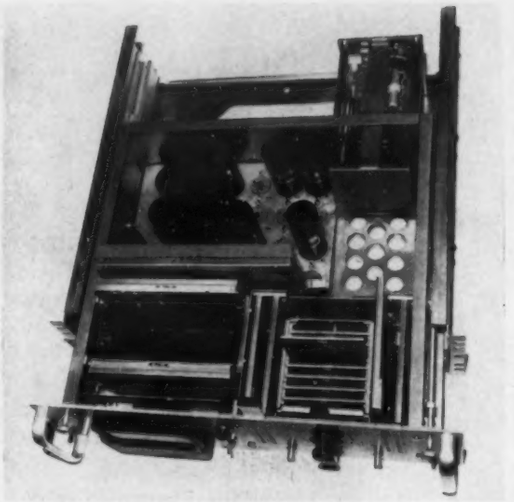

FIG. 5. BAND-SWITCHING version of discriminator uses a rotary switch to select channels. Individual channel characteristics are fixed by plug-in Magmeter modules.

Maximum flexibility and ease of maintenance are achieved by using the modula for construction. All that is necessary to convert the single-channel discriminators to operate on different frequencies is to plug in the proper Magmeter and bandpass filter modules. In the band-switching version (Fig. 5) channel selection is accomplished with a rotary switch (modules are plug-in).

The general advantage of this unique pulse averaging circuit is that solid state, passive elements (the Magmeter) determine its inherent linearity and stability. It is a low-cost open loop system, with extremely stable elements. All accessory circuitry is solid-state.

BOOK REVIEWS

ROCKET DEVELOPMENT, Robert H. Goddard, edited by Esther C. Goddard & G. Edward Pendray, Prentice-Hall, Inc., Englewood Cliffs, N. J. (1961), 222 p., 5½" x 8", $2.45 (paper bound). A re-issue of a compilation of Goddard's own writings on his significant rocket experiments from 1929 to 1941.

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TRANSMISSION OF INFORMATION, by Robert M. Fano (1961), John Wiley & Sons, Inc., 440 Park Ave., South New York 16, N. Y., 389 p., 6" x 9", $7.50. Presents foundations and major results of information theory. Presupposes a background of the foundations of probability theory and of Fourier analysis.

CIRCLE 120 ON READER-SERVICE CARD

ELEMENTS OF FLIGHT PROPULSION, by Joseph V. Foa (1960), John Wiley & Sons, Inc., 440 Park Ave., South, New York 16, N. Y., 445 p., 6" x 9", $12.50. Is guide for creative work and for evaluation of new ideas in propulsion engineering, rather than a source of data on existing propulsion devices.

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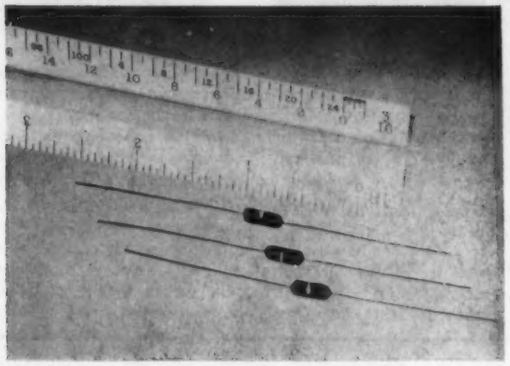

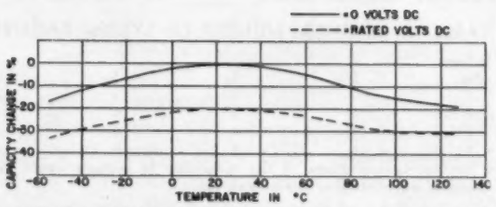

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Excitation	Fixed Phase	26v	26v	26v	115v	26v	26v	115v	115v	115v	115v
400 cycles	Control Phase	33v	33v	33/16.5v	33/16.5v	33/16.5v	33/16.5v	40/20v	40/20v	40/20v	40/20v
Length, inches		0.865	1.565	0.840	1.165	1.332	1.350	1.340	1.915	2.049	2.552
No-load speed, RPM		10,000	10,000	6,000	6,000	5,000	6,000	6,000	5,300	6,000	5,900
Torque at stall, oz. in. (nominal)		0.1	0.1	0.22	0.33	0.22	0.22	0.6	0.6	0.6	0.6
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Confidence Limits for System Reliability

Independent Subsystems in Series or Parallel*

NORMAN R. GARNER AND RICHARD W. VAIL, JR.
Aerojet-General Corporation

Mr. Garner, a member of Aerojet-General's Corporate Reliability Assurance Staff, has been associated with the Corporation since 1957 as a technical specialist in the application of statistics to research, reliability and quality control problems. He holds his B.A. in Mathematics from the Univ. of Rochester and his M.S. in statistics from N. Carolina State.

Mr. Vail, a statistical consultant assigned to the Corporate Reliability Assurance Staff, holds a B. A. in mathematics from the Univ. of Florida, and a M. S. in statistics from the Virginia Polytechnic Institute.

ENORMOUS expenses and hazards involved in full scale flight testing of modern missile and space systems have resulted in emphasizing subsystem testing for reliability demonstration. Although this type of testing generates extensive information concerning the reliabilities of the various subsystems, what information does it provide concerning the reliability of the overall system? An attempt to provide an answer to this question led to the establishment of the well known Product Rule. The Product Rule states that for systems composed of independent subsystems arranged in series the reliability of the system is equal to the product of the reliabilities of the various subsystems. A series arrangement means that the failure of any subsystem results in failure of the entire system. Thus the Product Rule gives a "best" single-valued estimate of system reliability based on subsystem testing.

Reliability requirements stated in most government contracts, however, are not in terms of this single-valued estimate, but rather in terms of a lower confidence limit for system reliability. This creates quite a problem to reliability engineers, since methods for combining subsystem reliabilities to obtain a lower confidence limit for system reliability are not well defined. This paper presents a relatively simple procedure for obtaining a lower confidence limit for system reliability when information is available only on subsystems. The procedure will be discussed and illustrated for series systems composed of unlike subsystems, and then extended to series systems composed of like items, and to parallel systems.

Series Systems Composed of Unlike Subsystems

Consider a simple missile system composed of only three functional subsystems: S_1, the ignition subsystem; S_2, the propulsion subsystem; and S_3, the warhead subsystem. Obviously these subsystems are arranged in a series configuration and are independent with respect to reliability. That is, a failure of any subsystem would result in the failure of the entire system, and the reliability of any subsystem does not affect the reliability of any other subsystem. Further, suppose that 100 tests have been made on each subsystem, with three failures being observed on S_1 ($f_1 = 3$), four failures being observed on S_2 ($f_2 = 4$), and one failure being observed on S_3 ($f_3 = 1$). It is desired to estimate from this information a 100γ percent lower confidence limit for system reliability, where γ is the desired confidence probability.

If these subsystems had been randomly mated and actually utilized, as few as four or as many as eight system failures could have been possible in our sample of 100 complete systems. The manners in which the minimum and maximum numbers could occur are tabulated in Table 1. This table shows that the minimum number of system failures is given by the maximum number of failures observed on any one subsystem, and the maximum number of system failures is given by the sum of all failures over all subsystems. In general, under random mating of m subsystems, there will occur f system failures, where

$$\max f_i \leq f \leq \sum_{i=1}^{m} f_i \qquad (1)$$

It is well known that for complete system testing in which f failures are observed in n trials, a 100γ percent lower confidence limit, $\underline{R}$, for system reliability is obtained by solving for $\underline{R}$ in the equation

$$\sum_{j=0}^{f} \frac{n!}{j!n\text{-}j!} (1-\underline{R})^j (\underline{R})^{n-j} = 1-\gamma \qquad (2)$$

Fortunately, Pachares[1] has prepared tables which are very useful in evaluating this equation.

The confidence limit determined by (2) is a valid estimate of this reliability for any particular sampling of complete systems. Thus, applying equation (2) to each f contained in (1), valid confidence limits for every possible sampling variation of complete sys-

TABLE 1A MINIMUM NUMBER OF SYSTEM FAILURES

Failure No.	S_1	S_2	S_3	S
1	x	x	x	x
2	x	x	o	x
3	x	x	o	x
4	o	x	o	x

x denotes failure. None of the remaining 96 systems would have failed, since no further subsystems fail.

TABLE 1B MAXIMUM NUMBER OF SYSTEM FAILURES

Failure No.	S_1	S_2	S_3	S
1	x	o	o	x
2	x	o	o	x
3	x	o	o	x
4	o	x	o	x
5	o	x	o	x
6	o	x	o	x
7	o	x	o	x
8	o	o	x	x

x denotes failure. None of the remaining 92 systems would have failed, since no further subsystems fail.

TABLE 2. COMPUTATIONS FOR 95% LOWER CONFIDENCE LIMIT FOR SIMPLE MISSILE SYSTEM

1. $R'_s = r'_1 r'_2 r'_3 =$ (0.97) (0.96) (0.99) $\cong$ 0.92

2. The possible number of observed system failures in the sample of 100 systems are $4 \leqq k \leqq 8$

3. k	p_k	$\underline{R}_k$	$p_k\underline{R}_k$
4	0.05363	0.91080	0.04884
5	0.08954	0.89775	0.08038
6	0.12328	0.88501	0.10910
7	0.14395	0.87254	0.12560
8	0.14552	0.86028	0.12519
	$\Sigma p_k = 0.55592$		$\Sigma p_k\underline{R}_k = 0.48911$

4. $\underline{R}_s = \dfrac{\Sigma p_k \underline{R}_k}{\Sigma p_k} = \dfrac{0.48911}{0.55592} = 0.88$

* This article is an extension of a paper presented by Mr. Garner at the Western Regional Quality Control Conference, Anaheim, California, March 16-17, 1961.

tems can be obtained. If the true population reliability were known, then the probability of obtaining each f contained in (1) could be determined. Using these probabilities as weights, a weighted average of possible confidence limits would thus provide a very good estimate of the 100γ percent lower confidence limit for system reliability. That is,

$$\underline{R}_s = \sum_{k=\max f_i}^{\sum_{i=1}^{m} f_i} p_k \underline{R}_k \Big/ \sum_{k=\max f_i}^{\sum_{i=1}^{m} f_i} p_k \qquad (3)$$

where $\underline{R}_s$ is the 100_γ percent lower confidence limit for the entire system,

p_k is the probability of observing j failures in a sample of size n if the reliability of the system is known,

$\underline{R}_k$ is the estimate of the 100γ percent lower confidence limit for j failures in a sample of size n, and

f_i is the number of failures observed on the *ith* subsystem.

Unfortunately, the true population reliability, R, is not known. In fact, it is the lower confidence estimate of this value which we are trying to compute. Therefore, it is impossible to determine the required weights, p_k, exactly. However, it is recommended that these weights be computed using the point estimate of system reliability obtained by the Product Rule. That is,

$$R'_s = r'_1 r'_2 r'_3 \ldots r'_m = \prod_{i=1}^{m} r'_i \qquad (4)$$

where r'_i is the estimated reliability (or success rate) of the *ith* subsystem. Thus, the proposed method for computing the 100γ percent lower confidence limit based on subsystem testing alone is given by equation (3), where each p_k is estimated by utilizing R'_s as the reliability of the system.

To illustrate this procedure, Table 2 gives the required steps and values needed to calculate the 95% lower confidence limit for the simple missile system previously discussed. The first step is to determine the estimate of system reliability, R'_s. This is the product of the estimated reliabilities for each of the subsystems. For example, with 3 failures in 100 tests, the estimated reliability for S_1 is $3/100 = .97$. Similarly, the estimated reliability for S_2 is .96 and for S_3 it is .99. Hence, the estimate of system reliability is .92. The second step is to determine the minimum and maximum numbers of failures according to equation (1) and demonstrated in Table 1. In the third step, the probabilities, p_k, of observing exactly k failures in 100 tests if the true probability of the system was .92 are first determined. These can be read directly from Binomial Tables (See Reference 2). Secondly, an estimate of the lower 95% confidence limits for k failures is determined. These are read directly from the tables prepared by Pachares. Then, for each k, the product

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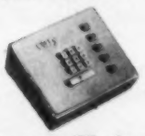

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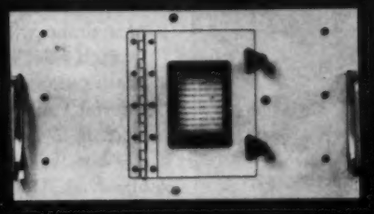

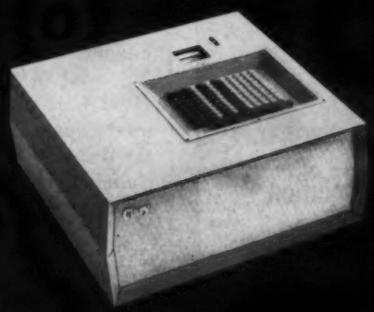

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of $p_k \underline{R}_k$ is determined. The last step is to evaluate the ratio

$$\underline{R}_s = \frac{\Sigma\, p_k R_k}{\Sigma\, p_k}$$

and is the estimate of the 95% lower confidence limit for the missile system reliability. It is calculated to be 0.88.

Series Systems Composed of Like Subsystems

The procedure presented is easily adaptable to systems composed of like subsystems. Examples of like subsystems are dual boosters attached to drones or air-breathing missiles, clustered rocket motors, etc. As a specific example consider the booster "system" of a drone which employ identical boosters mounted in each side. (In connection with the overall function of the drone, the booster "system" would be considered a subsystem, but for our purposes we will consider it to be a "system".) Assume that 100 tests of this booster have been performed and 10 failures were observed. Under random mating of two boosters to each drone, as few as $f = (10/2)$ or as many as 10 failures could have occurred during 50 system tests. Hence, for this situation we would have $5 \leq f \leq 10$, and $n = 50$. Further, the estimate of system reliability, R'_s, used in estimating the weights, p_k, would be $(0.90)^2 = 0.81$. This information would in turn be used to prepare a table similar to Table 2 to calculate the desired lower confidence limit, $\underline{R}_s$. The 95% lower confidence limit is calculated to be $\underline{0.73}$.

Parallel Systems

Extensions of the proposed procedure to parallel systems are similarly straightforward. However, systems composed of parallel subsystems have a different range of possible system failures which could result from random mating of the subsystems, and a different formula for estimating system reliability. Remember that these systems fail only when all subsystems fail.

The possible number of system failures for random mating of m unlike parallel subsystems is

$$0 \leq f \leq \min f_i \qquad (5)$$

and for random mating of m like parallel subsystems is

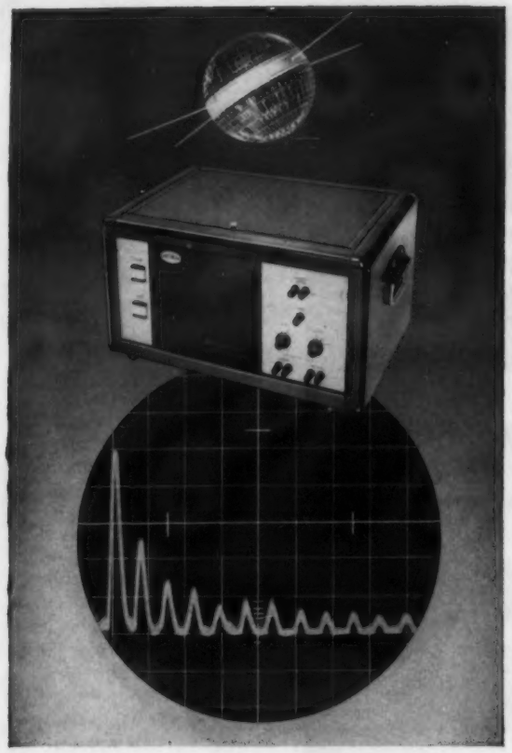
$$0 \leq f \leq f_i/m \qquad (6)$$

Here, f_i is the total number of failures observed on the one subsystem. If f_i/m is not a whole number, the number neglecting the fractions is used. The estimate of system reliability, R'_s, required for computing the weighting probabilities is

$$R'_s = 1 - (1 - r'_1)\,(1 - r'_2)\,(1 - r'_3) \ldots (1 - r'_m)$$

$$= 1 - \prod_{i=1}^{m} (1 - r'_i) \qquad (7)$$

where again r'_i is the estimated reliability of the *ith* subsystem.



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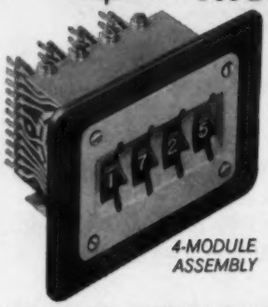

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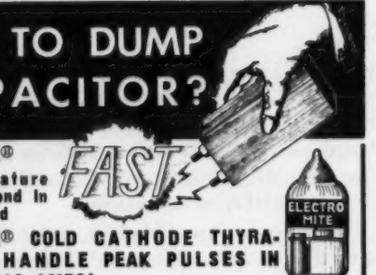

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Unequal Sample Sizes

The procedure recommended has considered only the situation when equal sample sizes were available for all subsystems. If unequal samples are available, the same procedure can be utilized; however, the sample size in the estimate can only be as large as the smallest sample size available, since this is the total number of systems that could possibly be tested. It must not be assumed, however, that the information contained in the larger samples is lost. Note that the procedure obviously becomes more "efficient" as the estimate of the population reliability becomes more "efficiently" estimated.

Results of Monte Carlo Experiments

A simple Monte Carlo procedure was programmed to evaluate the proposed methods for computing confidence limits. The method consists of sampling numbers at random, designating prior to sampling those numbers which would represent a failing subsystem. For example, if a subsystem was to have 95% reliability, numbers from 00 to 99 would be sampled with, for example, the numbers 95, 96, 97, 98 and 99 designating failure. Thus, the sampling was from known populations. Each time, m subsystems were simultaneously sampled, and as the sampling proceeded, each failure was recorded for each subsystem and the total number of failing systems were determined. Then, for comparison, confidence limits were computed as though the complete system were tested. In addition, confidence limits using the Poisson approximation to the binomial were computed using

$$\sum_{i=1}^{m} f_i$$

as the total number of defects. Frequency distributions of these confidence limits were compiled which clearly showed that the proposed method is always superior to the Poisson approximation, and also provides better estimates of confidence limits than would be obtained from complete system testing. The latter result would be expected, since this method takes into account all possible sampling variation arising from random fitting of subsystems to produce a single system. Copies of the results of the Monte Carlo experiment can be obtained from Corporate Reliability Assurance, Aerojet-General Corporation, Azusa, California.

References

[1]Pachares, J., "Tables of Confidence Limits for the Binominal Distribution", *Journal of the American Statistical Association*, 55, 1960, pp. 521-533.

[2]"Tables of the Binominal Probability Distribution", National Bureau of Standards, Applied Mathematics Series 6, Washington D.C., 1950.

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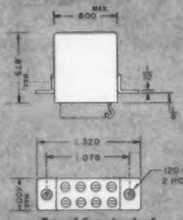

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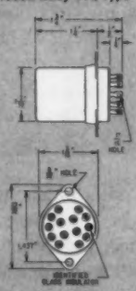

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Weight: 18 ± 1 Gram
Ambient Temperature: −65°C to +125°C
Contacts: 2PDT (2 Form C) 2A @ 30 VDC
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			Ohms	MA.	Volts		
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4A36-B	4	3 AMPS 30VDC	300	41	26.5	Dry Ckt. Capability	2
4C36-B	4	5 AMPS 30VDC	300	41	26.5	Heavy Duty	1
2B36-B	2	10 AMPS 30VDC	300	41	26.5	Heavy Duty	4
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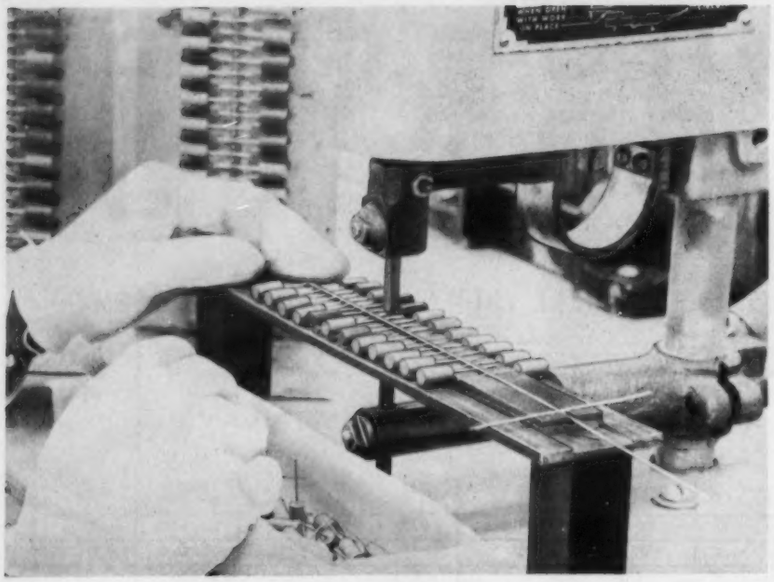

Manufacture of High

FIG. 1. SINTERED TANTALUM porous slug is electrically welded to rack preparatory to anodizing and later steps in the manufacture of solid electrolyte capacitors.

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THAT TANTALUM metal forms an oxide of relatively high dielectric constant and good dielectric strength has been known for a considerable time. However, only in the past few years have any considerable number of tantalum oxide capacitors been produced. This relatively long period has been due to a number of factors, which include the difficulties of preparing a suitably pure tantalum from its ores, the complicated metallurgy of the element, and the extensive research and development required to produce operating capacitor structures.

Currently, the family of tantalum capacitors includes foil, wet-slug, wire, and solid electrolyte types. Although each type offers an exciting opportunity for technical discussion it is proposed here to deal only with the most recently developed member of this family, the solid electrolyte tantalum capacitor.

The recovery of tantalum in a sufficiently pure state for use is a complicated metallurgical process. It is important to obtain the tantalum in a suitable particle shape and size for subsequent pressing and sintering into the anodes used for capacitor manufacture. This part of the process is most carefully guarded by individual manufacturers.

General Considerations

The solid-electrolyte tantalum capacitor is fundamentally different from any previous electrolytic capacitor, either aluminum or tantalum, in that it comprises solely inorganic materials having no liquids or other volatile constituents. While this affords important advantages, it also necessitates scrupulous cleanliness and uniformity of process operation, making the manufacture of tantalum capacitors analogous to that of semiconductor devices such as transistors and diodes.

The anode of the capacitor consists of a porous slug prepared by sintering a pressed mass of tantalum powder at high temperatures and reduced pressures. The surfaces of this slug are anodically coated with a dielectric layer of tantalum oxide (Figs. 1 & 2) which is then covered with a thin layer of electronically conducting manganese dioxide. Improved electrical contact is made to the coating of manganese dioxide by means of graphite and conducting silver paste. The units are then soldered into a metal case, given an aging treatment, and inspected for initial electrical characteristics.

Since the oxide film is formed *in situ*, and is in the order of hundreds of Angstroms in thickness, any minute imperfections in the surface purity of the tantalum have a profound effect on the properties of the capacitor, especially as regards the leakage current and the ability to form the oxide film to higher voltages without crystallization.

The only presently known methods of applying the manganese dioxide coating to the oxide film, together with the subsequent graphite coating, require that the pore size and pore openings of the sintered slug be sufficient for proper penetration. At the same time, the density of the slug must be kept high for maximum capacity per unit volume. These opposing considerations operate in the design of any sintered anode from a particular tantalum powder.

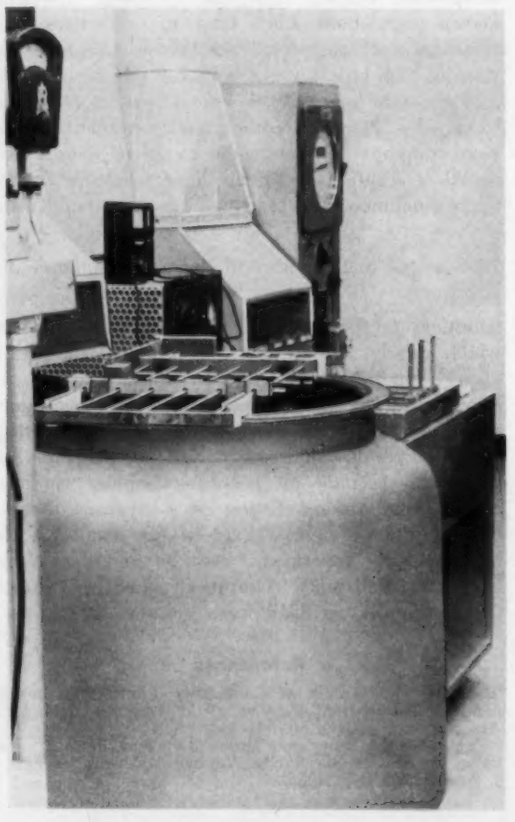

FIG. 2. ANODIZING TANKS in which porous metallic slug electrolytically receives the dielectric layer of tantalum oxide.

Reliability Solid-Electrolyte Tantalum Capacitors

The tantalum-oxide film, having a dielectric constant of 22 (as compared to 9 for the aluminum oxide film conventionally present in the aluminum electrolytic capacitor) is formed under the influence of the high electric field existing in the anodizing bath by the movement of tantalum ions through the already existing oxide film on the surface, and their reaction with oxygen atoms adsorbed on the same surface and derived from the decomposition of the electrolyte under the same surface and under the same electric field.

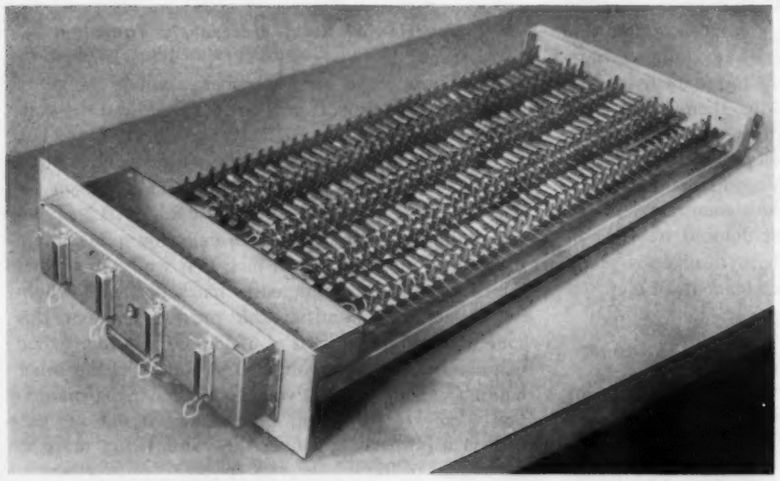

FIG. 3. COMPLETED CAPACITORS are hermetically sealed in cases and clipped in drawer rack to be aged and life-tested.

FIG. 4. CLEAN ROOM Methods of manufacture compare with those used in semi-conductor device fabrication, are conducted in room-within-a-room under controlled conditions of temperature, humidity and dust content.

Under these circumstances the oxide formed by the anodization is not the stoichiometric Ta_2O_5 but varies in composition with depth, being richer in oxygen at the electrolyte interface and containing excess tantalum ions towards the metal. This slight excess of tantalum ions is the cause of the n-type nature of the oxide film.

Unfortunately, the building up of the oxide film is usually accompanied by slight imperfections in the structure, as mentioned before, occasioned by surface impurities; these imperfections are the major cause of the leakage current observed in the finished capacitor. In the solid-electrolyte tantalum capacitor, these imperfections are believed to be healed by the donation of oxygen atoms from the semiconductor manganese dioxide, the solid electrolyte used. This reaction probably involves an oxidation of the exposed metal at the base of the imperfection and a reduction of the manganese dioxide due to the high electric fields present, thus forming a substantially non-conducting "plug" which prevents the high leakage currents that would otherwise be present.

This "plugging" is the major reason why the solid-electrolyte capacitor does not exhibit an initial surge of current when first energized, as compared with types using a liquid electrolyte.

The capacitance of the solid electrolyte tantalum capacitor is remarkably stable either with shelf-storage, or on load, and test data up to 15,000 hours on load at 85°C are available. This appears to be in marked contrast with the relatively unstable aluminum oxide, probably because the lattice structure of the tantalum oxide fits very closely to that of the tantalum metal substrate, whereas that of aluminum oxide does not, causing the latter to be under strain and enhancing its tendency to attack from contacting electrolytes.

On the other hand, it is well known that it is possible to observe momentary breakdowns in the dielectric oxide film which immediately "self heal" due to the local heating caused by current at the weak spot. An examination of the capacitor immediately after such a momentary breakdown will show absolutely no change in the electrical properties.

Different conditions of life testing lead to conflicting conclusions. When first proposed, life testing was performed at 85°C at rated voltage with a 1000-

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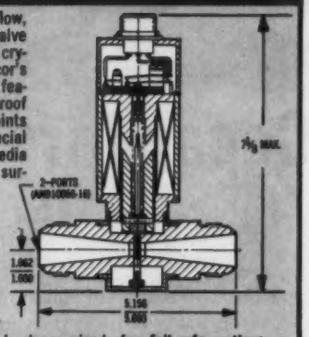

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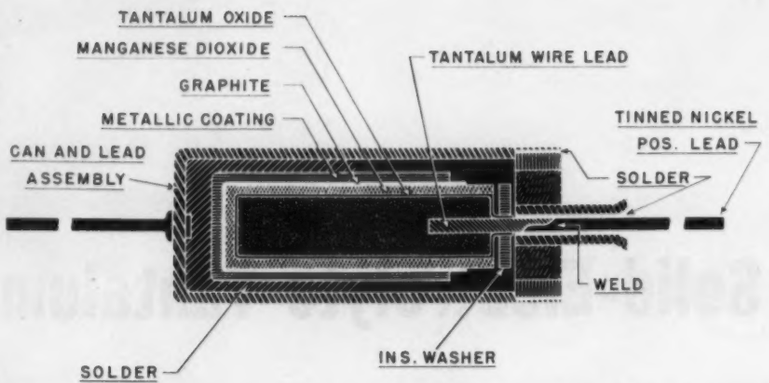

FIG. 5. CROSS SECTION of "Aerotan" Solid Electrolyte Tantalum Capacitor.

ohm current limiting resistor in series with the capacitor. It was then suggested that testing at 125°C would accelerate the life test. Trials showed that, even with a resistor in the circuit, these capacitors would fail differently from those tested at 85° C. The final MIL-C-26655A specification calls for 65°C aging without resistors at rated voltage, and 125°C without resistors at derated voltage (Fig. 3).

Various other life tests have been devised and have found their way into practice, creating considerable confusion and making it necessary to examine with extreme care various claims to life test data extending over 10,000 hours, when evaluating them against the recently issued military specification.

Of special interest is one accelerated test which attempts to simulate the conditions in computer circuits. Here the momentary failure mentioned above is of great importance. This test devised by IBM in effect counts the number of these discharges while maintaining the capacitors under load at an elevated temperature.

Manufacturing Facilities

Facilities installed by the Aerovox Corporation for the manufacture of the capacitors enable a higher range of uniformity and reliability than have heretofore been possible.

Basically all operations of capacitor manufacture are performed in a specially constructed room-within-a-room (Fig. 4) under controlled conditions of temperature, humidity and dust content. Also, demineralized water of not less than 1.5 megohms/cc is used. This is led from special storage tanks to the manufacturing oven through plastic piping.

Properties of Solid Electrolyte Tantalum Capacitors

Four basic case sizes cover the whole range of "Aerotan" capacitors from 1 μf to 330 μf, and the voltages available are 6, 10, 15, 20 and 35 (Fig. 5). Unfortunately MIL-C-26655A, although recognizing a different value of leakage current for any given capacitor voltage and capacitance, namely, 0.2 μf per μfv, independent of case size, calls for a maximum dissipation factor of 6%. In fact, it is well known that the dissipation factor increases markedly at the highest capacitances, and at the present moment this somewhat arbitrary limit of 6% can be a burden when manufacturing the 6 volt, 330 μf unit. On the other hand, a capacitor of 20 volt, 100 μf having a dissipation factor of 6% would be considered out of control on a properly run line, the value being more in the region of 3%.

High-Speed Data Camera Adds 3-D

A new industrial and scientific observation camera —the Stereoflex—for reducing fast-moving phenomena in solid space to slow motion, has been developed by the Benson-Lehner Corporation, Santa, Monica, Calif., for a research program at the Naval Weapons Laboratory, Dahlgren, Va.

Rapid motion photography has, to date, been able to record only the lateral, two-dimension effect of explosions and similar reactions. The new camera (Fig. 1) records two 16mm images side by side on a single strip of 35-mm film. These images are reflected from the object under study by two movable mirrors (Fig. 2), by which the convergence can be varied. If a combination of telephoto lenses and a wide distance between mirrors is used, an optical effect is achieved equivalent to the view seen by a person only few feet distant, but in perfect safety to the camera and operators.

The Stereoflex employs a 24-facet rotating prism to arrest motion of the image relative to the continuously moving film. This method, similar to that used in many high speed data cameras, requires the

Stereoflex film to accelerate from a stationary position to 15,000 fps in 0.5 to 0.6 seconds. This high acceleration enables 80% of the film to be exposed at optimum speed. In the past, this figure has been as low as 10% to 20%. The camera loads with 400 ft of

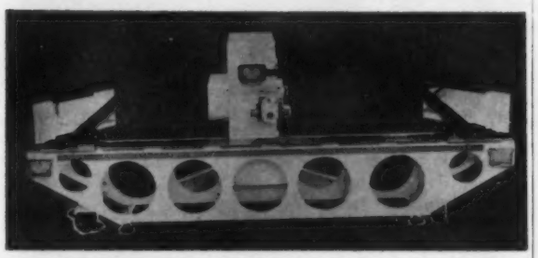

FIG. 1. STEREO is added to ultra high speed operation in new Stereoflex data camera.

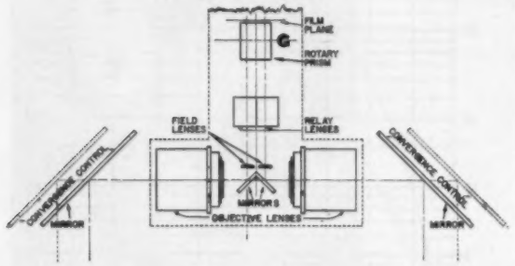

FIG. 2. LENS AND MIRROR optical system gives wide interpupillary separation for stereo effect at telescopic distances. Adjustable side mirrors regulate convergence, are expendable for explosives study.

35mm film which has four rows of perforations, two of which run down the middle of the film between the two 16mm images. The driving motor is a 208 v 3-phase synchronous motor. It develops up to 7.5 hp.

A neon timing light records real time references directly on the film at adjustable intervals up to 1000 times per second. In studying explosives, the ¾" thick, front-surface mirrors are broken with each explosion, and are constructed so that the shock they receive is not transmitted to the mount or camera. A single convergence control screw simultaneously adjusts both mirrors.

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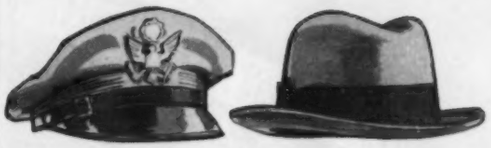

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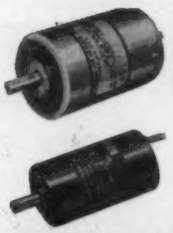

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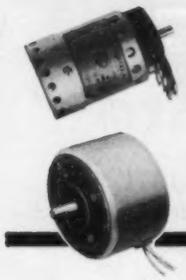

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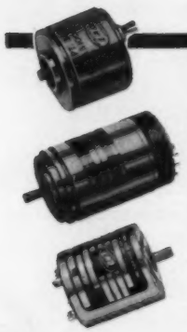

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Modules Speed Prototype Delay Design

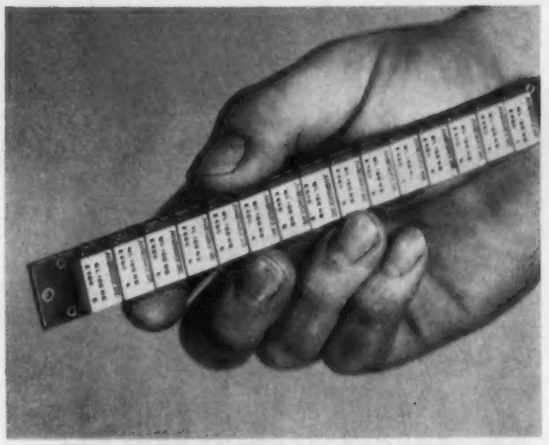


FIG. 1. SECTIONALIZED Delay Lines, called "Wee Lines"® offer a speedy method to obtain peculiar delay lines needed for any prototype application.

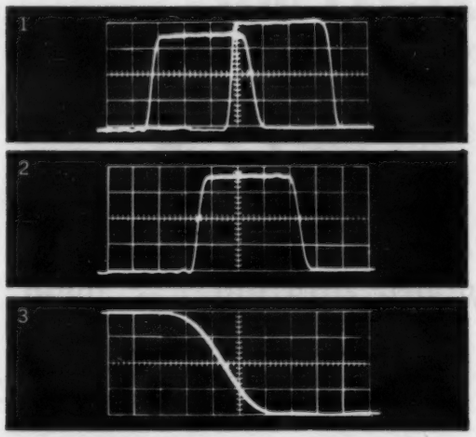


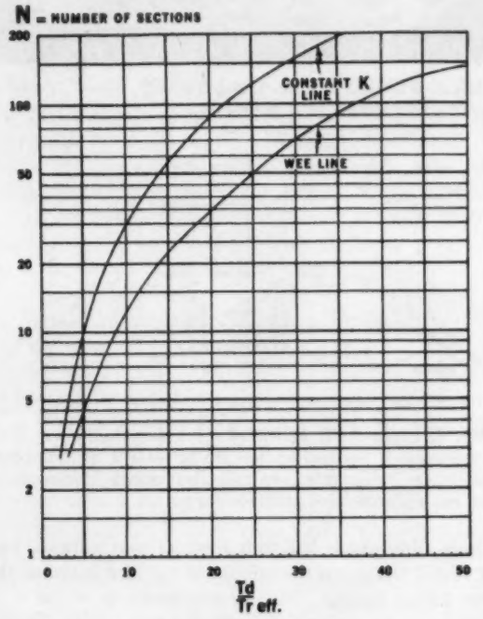
FIG. 2. STANDARDIZED Characteristics for each type of section ensure that the engineer gets identical performance from every unit. Oscillogram (1) shows input-output pulse relationship (2) output pulse; (3) rise time.

Delay Lines for prototype circuits are frequently "one-of-a-kind" items. The design engineer must not only determine the characteristics of the prototype line but must also consider possible sources of supply and effects of delivery time on his work schedule. A new delay line built of standardized modular increments, called "Wee Lines", is now available from Nytronics, Inc.

"Wee Line" sections are produced with delay times of from 10 nsec to 100 nsec in 10 nsec increments (Fig. 1). Standardized at 6, 15, 30, 45, and 60 sections per line, the lines may be stacked to provide 200 sections or more.

Each section is an encapsulated unit, consisting of a basic LC circuit with phase correction for proper pulse response, and the lines are designed so that taps may be pulled at any increment of delay without distorting pulse shape. Standardization is such that any number of lines selected at random will exhibit identical performance characteristics (Fig. 2).

Design of a prototype delay line using "Wee Lines" is a simple procedure using the graph shown in Fig. 3 which considers the factors, delay time, rise time and impedance value. For example, if an engineer requires a line with a delay time of 2.9 μsec, rise time of 0.1 μsec and an impedance of 500 ohms, the delay to rise time ratio is first calculated; $T_d/T_r = 2.9/0.1 = 29$ On



$$T_{r\,eff.} = \sqrt{T_{r\,OUT}^2 - T_{r\,IN}^2}$$

IF $T_{r\,OUT} \geq 10 \times T_{r\,IN}$, $T_{r\,eff.} = T_{r\,OUT}$

FIG. 3. DELAY LINE Design Graph.

the curve, go out on the T_d/T_r *eff* scale to 29, go up to the intersection with the Wee Line curve at 68 sections, which indicates the number of sections needed. To establish the delay per cell, the total delay 2.9 is divided by the number of cells to be used (68). $2.9/68 = .0426$ μsec per cell. Since this value is between the standard values listed, the next lowest increment of delay listed is selected, in this case 0.04 μsec/cell. $2.9/0.04 = 72$ cells of 0.04 μsec plus one cell of 0.02 μsec to give the exact value of delay, and to maintain a minimum delay to rise time ratio of 29/1.

A fifteen-section Wee Line is 7.141″ long, 0.675″ wide and 0.330″ high. The dimensions of lines with more or fewer sections varies proportionately, and they may be stacked or canned as use specifications may dictate. Each section is encapsulated to meet the requirements of MILC-15305B, Grade 1, Class B.—(*From 4-page brochure, Nytronics, Inc., 550 Springfield Ave., Berkeley Heights, N. J.*)

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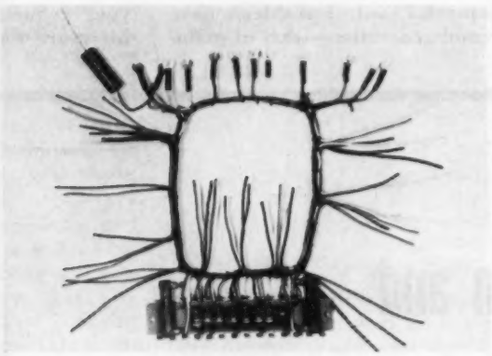

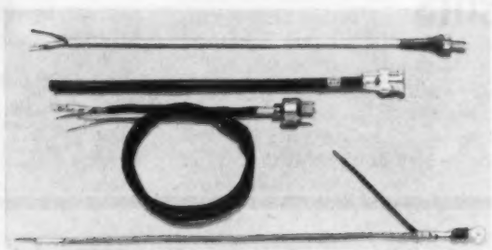

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■ **MILITARY SYSTEMS DESIGN recently received the following inquiry from the Commanding General, Sacramento Air Material Area Command, McClellan Air Force Base, Calif:**

"This command operates an instrument repair shop of considerable size. Aircraft instruments of all types are being handled and a constant effort is being made to keep abreast of advancing technology in this field. As aircraft have developed to the supersonic stage along with the advent of space vehicles, instrumentation has become so delicate the ordinary repair methods no longer suffice.

"This activity realizes that special precautions must be observed when handling this type of instrument and has arrived at the conclusion that a modern facility with an environmentally controlled atmosphere (clean room) is a necessity. To provide this, establishing a "clean room" requires consideration of such special features as air locks, garment cleaners, dust monitoring, personnel restrictions, etc.

"This command is experiencing difficulty in obtaining information with respect to establishing, operating and control of such a room. If the editors of your publication have knowledge of any such information and where it may be obtained, it is requested that this depot be advised. All information will be greatly appreciated."

This inquiry forcefully brought to our attention the fact the environmental control problems have now entered the second generation—that of maintenance. Many of the same problems which have confronted manufacturers in ever increasing degree in the last decade are now beginning to concern those responsible for the maintenance of those systems.

Because the type of "Clean Room" or work space varies greatly depending on the products produced, adjusted or repaired, this article will attempt to describe some of the numerous factors involved in the design of different types of clean rooms. Literature and products related to Clean Rooms are listed at the end of the article. These are keyed with MILITARY SYSTEMS DESIGN reader service card numbers to facilitate your request for additional information or the literature described.

Environmental Control in Production and Maintenance of Electronic Components

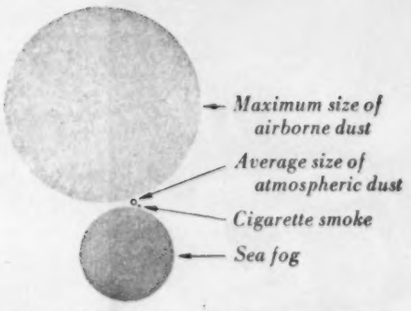

FIG. 1. RELATIVE size of common filterable particles if a pin-hole were 12" in diameter. **Courtesy Air Filter Handbook, Farr Co., Los Angeles, Calif.**

Environmental Control—and Who Needs It

Manufacturers and Research activities engaged in the industries which produce the products listed in Table I are among those who find some degree of "Clean Room" measures necessary to their enterprise. The degree to which dust and humidity control is necessary varies with the product. The terms "dust controlled area", "clean room" or "white room" are used interchangeably in the literature. The following definition fits any of the three terms:

"A white room is a space (single room or major portion of a plant) in which cleanliness, temperature and humidity are regulated to a far higher degree than in conventional air conditioning."

Many plants have dust-controlled room classifications. Minimum control would qualify an area as a "grey room" or "sub-clean" area. Next would be a "clean or white room" and finally the Class "A" or "super-clean" area. Mr. W. R. Jerome of Autonetics, defines a Class "A" dust controlled area as: "A Sterilshield® cabinet inside a dust controlled room. The equipment supporting the cabinet is capable of 0.3 micron filtration with over 99% efficiency."

The micron (μ), one millionth of a meter (10^{-3} mm) is the unit employed in dust particle measurements. Fig. 1 shows sizes of particles relative to a pin hole enlarged to 1 ft diameter.

Nature of Problem

In describing the purpose of dust control in his plant, Mr. C. P. Shelly, supervisor of the Optical-Mechanical Precision Assembly of Nortronics Division, Northrop Corp., stated in an article in Plant Engineering Magazine, March 1961:

"A large proportion of the parts being assembled are so small that the work must be done under a microscope. The finished part may be the size of a match head. On it may be hand wound several coils of wire, with each wire one-fifth the diameter of a human hair. Solder connections are accomplished with a soldering iron the size of a sewing needle.

"Many of the angular components must be accurate to within one second of arc. This is equal to the angle through which the eye would switch in viewing the two edges of a dime 2½ miles away.

"With such accuracies to maintain, it is not hard to imagine the effects of a speck of dust separating two fitted surfaces, or what occurs if the part is expanded or contracted by a change in temperature, if a slight amount of surface oxidation occurs, or if the volume of a part increases slightly because of moisture absorption."

In many other areas a similar or even higher degree of dust control is required. Computer research in Cryotron thin films is using filters down to 0.1 micron. In San Antonio, cancer research is being carried on with air filtered free of particles over 0.1 micron.

Research into the factors affecting the reliability of transistors and other miniature semiconductors devices has established that contamination by dust and moisture during manufacture are often to blame for early failure of individual units. Recognizing the importance of environment control the Air Force has set up stringent requirements for contractors undertaking to produce the ultra-reliable transistors needed in its MINUTEMAN Missile program. The reliability standard for these transistors has been set at ten times

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that of the best transistors available only a year ago—they must have a theoretical life of from 10 million to 100 million hours. The RCA plant at Somerville, N. J. has been designed to meet these specifications and is currently in production (Fig. 2).

Every indication is that increasing demands for microcircuits and other sophisticated semiconductor devices will require greater use of clean room techniques. Also manufacturers of many conventional components, such as small motors, resistors, capacitors, small coils and relays have discovered that clean-room manufacturing disciplines, followed by hermetic sealing of the component, are necessary to ensure the reliability required by military standards.

As stated before, the type and degree of environment control will vary with each product. In each case the control will be dictated; first, by the requirements of the operation and second, by the cost of the environment control. In the case of many research and military producton operations, no cost required to produce the necessary reliability is considered too high. In the case of competitive products, however, the cost factor becomes very important.

In any manufacturing operation, advice from competent consulting engineers specializing in environmental control will be valuable in achieving adequate control at the lowest cost. Another factor to be considered is the adaptability of a system to changing (unusually more stringent) requirements. This is one field in which the state of the art is anything but static. Some general considerations, offered by The Baker Company, consultants and manufacturers of Clean Room equipment, follow:

Controlled environments commonly considered are: (1) Dust free, (2) moisture free, which can be either dried dust-free air or gas, as required, (3) microbe or virus-free air and (4) temperature control used in conjunction with any of the first three environments.

FIG. 2. TRANSISTORS for MINUTEMAN are produced in new RCA Clean Room facilities at Somerville, N. J. Sterilshield workspaces (right rear) accommodate workers using binocular microscopes. Sterilshield dry boxes (left) appear to form a "welcoming committee." **Courtesy ELECTRONIC AGE magazine.**

Dust Control

Choosing the proper equipment to provide the best economical solution to solve a specific control problem requires careful planning. Equipment purchased to meet a specific immediate need should be chosen after consideration of how such equipment can be integrated into the ultimate clean factory.

The size of the piece to be manufactured, the size and types of machinery and operations to be performed, the flow of the production line, even the comfort and convenience of the worker are serious considerations in the selection of methods to provide the proper environment.

For example, if parts are relatively small and easily handled, the most flexible, most economical and highest efficiency work area dust control is available in the form of Sterilshield or dust free workspaces (Fig. 2) which are pressurized with air through an "Absolute" mechanical filter. These cabinets are designed so they can be arranged side-by-side or back-to-back in rows with pass-through apertures between work stations so that work can pass with ease from one operation to the next. Full-width access slots and wide plate glass view screens contribute to the comfort, freedom of motion and resultant efficiency of the worker.

Individual work spaces make it possible to isolate the dust- or dirt-generating operations so that these necessary but trouble-making spots do not contaminate other critical work areas.

The cost of maintaining the Sterilshield workspace at top efficiency is low. Housekeeping is nil compared to a room where people, machinery and vast working surfaces are continually generating troublesome dust. Only the operator's hands and wrists need enter the clean atmosphere of the workspace and, if the requirement is stringent, lint-free gloves can be used.

The amount of control advisable in different work areas is indicated by the following tables taken from Baker Co., reports.

TABLE I. INDUSTRIES AND PRODUCTS REQUIRING ENVIRONMENTAL CONTROL MEASURES.[1]

Industries	
Aircraft and Aeronautical Parts	Pneumatic Servos and Valves
Atomic Energy	Medical Research
Bearings	Optical Equipment
Boron (Solid Fuels)	Pharmaceuticals
Electrical Equipment	Relays
Electronic Data Processing	Semiconductors
Electronic Measuring Instruments	Vacuum Tubes
Film Products	Anti-Virus and Antitoxins
Missiles and Rockets	Armed Forces Repair Activities
Inertial Guidance Instruments	Alternation and Repair Shops
Liquid Oxygen (LOX)	Fourth Echelon Repair Shops
Electro-mechanical Servos	Repair Ships and Tenders
Hydraulic Servos and Valves	Industries

Products	
*Accelerometers	*Miniature Motors
Analyzers	*Potentiometers, Automatic
Automatic Transmissions	
*Ball Bearings, Micro	*Recorders
Micro-clutches	Resolvers
Computers, Analog	Rectifiers
*Control Systems	*Temperature Controls
Cavities, Microwave	*Transistors
Calorimeters, Microwave	*Transducers
Couplers	Tubing, Capillary
*Diodes	Vacuum Tubes, Receiving
*Gyroscopes	*Electrometer Tubes
Microammeters	*Television Camera Tubes
Microfaradmeters	Cathode Ray Tubes
*Magnetic Tape	Computers, Digital
*Magnetometers	*Cryotrons, Thin Film

*Highly Critical Products.
[1]*Courtesy, Angelica Uniform Co.*

***CLEAN ROOM* (Project ARF C 800)**

Location	Number of particles 0.5 to 5.6 μ dia/liter (No particles > 4.0 μ dia)
General Plant	79,000
Semi-Clean Area	996
Clean Room	275

***PRESSURIZED WORKSPACE* (Project 3812-4)**

Air Inlet	11,550
Sterilshield Outlet	47

Using the Sterilshield pressurized workspaces located within a clean room combines the efficiency of both to provide even better results.

Large Area Dust Control

When large or difficult-to-handle pieces must be made in a clean area or when the processes, methods or equipment do not lend themselves to the Sterilshield type of facility, a Clean Room installation must be used. Excellent results can be obtained if it is carefully planned and meticulously maintained. Materials, processes, etc., which are dust generators must be installed in exhausted cabinets or excluded from the clean room to minimize the number of dust particles which get into the air of the room (Fig. 3).

Mr. Lieberman of Armour Research Foundation of Ilinois Institute of Technology states in his paper entitled, "Determination and Detection of Air Contaminants," that vinyl bench top material, when flexed, generates particles up to 32 μ dia; when rubbed. generate 16 μ particles and when abraided particles up to 64 μ are released. Oxidation-resistant coated metals release particles up to 8 μ when handled. Screw seating, belt drives and nylon-metal gear trains generate particles up to 32 μ diameter. Crumpling paper, 64 μ; writing on paper with ball-point pen up to 16 μ and even skin abrasion generates particles up to 4.0 μ in diameter."

It is obvious that careful training of personnel and that a well-planned and policed cleaning program is as important as the careful choice of materials and the design of the room itself.

Clean Room Layout

Basically, a room layout should consist of a gowning room for storage of clean room gowns and dressing of personnel; an Air Shower to de-dust personnel (Fig. 4), an air lock to isolate the Clean Room from the Air Shower and finally the clean area itself. The clean area may be partitioned into several rooms so that one or more of these rooms can be maintained at a higher degree of cleanliness. The air system must be designed to completely recirculate the total room volume between 12 and 20 times each hour. Air diffusion at this rate must be designed to gently "sweep" the walls and floors toward the outlet grilles. Wall and floor surfaces should be electrically conductive so that static charges will not cause dust particles to cling, but instead will allow them to remain in air suspension and be swept out of the room.

The pressure in the cleaner area must be maintained above that in the surrounding areas. Pressures from 0.1" to 1" WG are practical and adequate.

Personnel Regulations

Unless well-planned regulations regarding usage and personnel are observed, the engineering skill and costly equipment expended on construction of the clean room will be wasted. The following set of regulations compiled by C. F. Schmid, Mgr. Plant and Engineering Facilities, Kearfott Division, General Precision, Inc., are typical of the measures which must be carefully enforced:

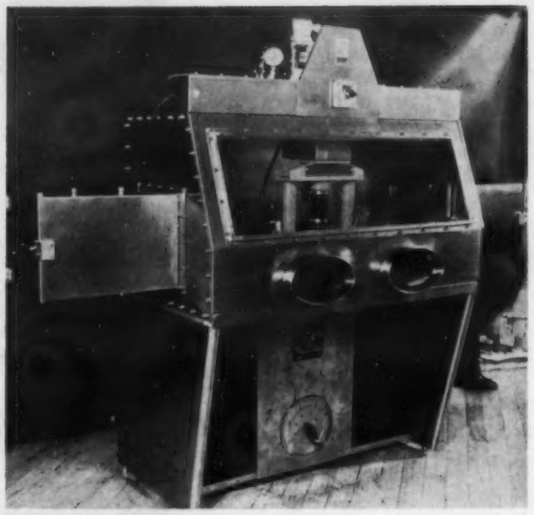

FIG. 3. STERILSHIELD Welder Dry Box with pass-thru air locks, is typical of use of dry box to enclose dust-producing operations or operations requiring special atmospheres. **Courtesy The Baker Co.**

FIG. 4. AIR SHOWER Grille for dust removal from shoes and clothing prior to entering clean room spaces, as installed in new **C. P. Clare & Co.**, Chicago relay plant.

1. Do not wear nail polish.
2. Thoroughly wash hands and scrub fingernails.
3. Thoroughly dry hands with hot air.
4. Do not walk about rooms unnecessarily. Use Intercom.
5. Always wear required garments.
6. Hair cuts are to be as short as socially tolerable.
7. Female employees are to tuck hair inside head covering.
8. Do not comb your hair in the "clean room".
9. Do not wear wrist watches or rings in pressurized hoods or during critical assembly operations.
10. Pencils and/or erasers cannot be used. Ball point pens will be provided.
11. No papers of any kind will be allowed in these areas. Glasene or acetate writing sheets will be provided.
12. Only test fixtures, tools, jigs and assembly fixtures need to perform the work required will be permitted.
13. No abrasive instruments such as crocus cloth, files, etc. are permitted.
14. Each employee is responsible for a high degree of cleanliness and neatness in maintaining his work station.
15. Foods of any kind are prohibited.
16. No smoking.
17. Boots, garments and hats must be thoroughly tied and buttoned at ankles, collars, and wrists.
18. No shredding tapes or masking tapes permitted.
19. No painted material allowed in the area.
20. No personal items—handkerchiefs, tissues, keys, etc. permitted in "clean rooms".
21. Use protective finger coverings as instructed.
22. Store surplus materials in containers provided.
23. Never leave exposed parts on work benches.
24. Follow prescribed procedures on entering and leaving the "clean room".
25. Materials are to be transferred through pass-throughs provided.
26. Check your uniform, hat, and boots for ravelled or frayed edges.
27. Enter and leave rooms at a slow gait.
28. Report any irregularities to your supervisor.
29. If you have a cold or are developing a skin condition, notify your supervisor.

It will be recognized that problems in employee relationships may arise from the necessity of enforcing the restrictions on cosmetics, nail polish and requirements for female workers to wear unflattering head coverings. The maintenance of a worker morale highly favorable toward the maintenance of low dust count and consequent high reliability in the product will do much to prevent worker dissatisfaction.

Moisture Control Methods

Providing a work environment which is free from moisture as well as dust poses even more problems. Many transistors must be formed in atmospheres which contain no more than 10 ppm water and some operations are working on as low as 2 ppm of water. It is obvious that a special room will not provide this

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Yes, ASTEK is a very young company but its engineering capability was **not** born yesterday. Its engineers have helped blaze the trail in aircraft and missile development over the past twenty years. They set the world's standard for such critical military and airline instrumentation as altimeters, machmeters, air data computers, and cabin pressure control systems. And the experience of ASTEK management in airline operation is reflected in its policy of providing off-the-shelf delivery – superior field service – operational and maintenance training – on-time delivery of maintenance manuals and parts lists.

ASTEK engineers have an unparalleled history of instrument and system designs. Some of their recent unique developments are:

■ DUALTIMETER – a precision altitude servo indicator with fail-safe operation. ■ AIRSPEEDATA – a combination air speed and mach indicator with "max.-allowable" and V. indications. ■ AUTOCONTROL – a cabin pressure control system requiring absolute minimum adjustment by flight crew. ■ HELIPANEL – a combined flight instrument for helicopters.

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degree of control. This dry atmosphere would be disastrous in its effect on the human body. Also, because of the amount of water the body exudes through lungs and skin, even a few persons in such a room would make control at such low dew-points virtually impossible.

To overcome these and other pitfalls, dry boxes (Fig. 5) were developed. Utilizing most of the desirable features of the Sterilshield pressurized cabinets, these work spaces are completely T.I.G. welded and

FIG. 5. DELICATE assembly operations are performed in dust- and moisture-free environments within Dry Box. **Courtesy The Baker Co.**

gasketed at all junctures with neoprene or silicone rubber gasketing, so that the envelope of the work area is absolutely gas tight. Parts are introduced into or removed from these work spaces through double-door gas locks, fitted with valving to allow complete flushing with dry clean gas to ensure that no contaminant or moisture is introduced along with the parts.

The advent of micro-miniaturization and molecular electronics engineering at the Westinghouse Air Arm Division plant in Baltimore, Md., recently introduced new stringent requirements for humidity and dust control, when an additional 1,800 square feet of floor space was devoted to their development. In this area a product can be manufactured entirely in chambers where the relative humidity is maintained at less than 1% and the air is filtered to remove all particles above 0.5 micron in diameter. Raw materials are received from suppliers in sealed containers which enter the control chamber (Fig. 6) to be opened and processed. The finished product does not emerge until it has been fully tested and encapsulated to protect it from the outside atmosphere. These techniques provide the Air Arm Division with the capability to accomplish super clean assemblies and to perform operations where the humidity must be so low that human operators could not long survive.

Humidity Control in Semiconductor Plant

Some considerations of humidity control in a modern semiconductor manufacturing facility are contributed by Mr. Paul R. Wathen, Works Engineer,

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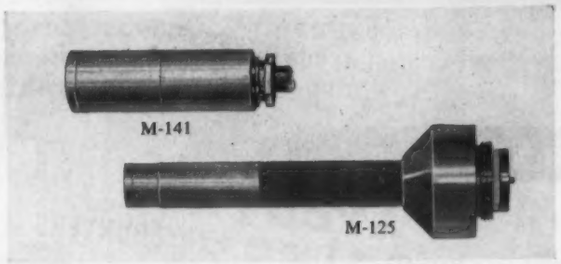

are selected for exacting applications in

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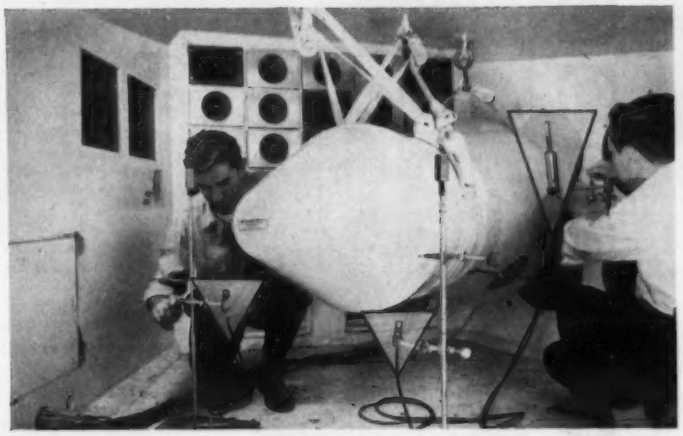

Three Massa Microphones (two M-141's and an M-125) with M-114B Preamplifier measure sound levels which simulate missile noise.

MASSA A.D.P. (Ammonium Di-Hydrogen Phosphate) Sound Pressure Microphones are used to measure sound pressure levels in an acoustic chamber at the Avco Research Center, Wilmington, Mass. Missile sound is simulated by noise generators that reach intensities as high as 143 db *. Placed at strategic locations, the Massa S.P. Microphones accurately determine that specified sound levels are reached at critical points on the vehicle.

Massa Sound Pressure Microphones employ A.D.P. crystal plates as the mechanical impedance determining element which results in an exceptionally stable vibrating system that does not distort the sound field in which the microphone is placed. A.D.P. crystal plates are employed as the active elements for best combination of reliability, stability and accuracy. The frequency response, essentially flat from 10 cps to 80 kc, extends well into the ultrasonic region. The dynamic range is linear to levels in excess of 200 db.

* Above 0.0002 dynes/cm²

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FIG. 6. SEMICONDUCTOR Assembly line in Air Arm Division, Westinghouse Electric Co., conducts all operations from opening of sealed containers holding raw materials to the hermetic sealing of the completed microcircuit, in Plexiglas HYDROVOID Cabinet atmosphere of less than 1% relative humidity. **Courtesy Air Control, Inc., Narberth, Pa.**

Semiconductor Dept., Westinghouse Youngwood, Pa., plant.

Commercial drying of air is not new, though the dew point and purity required for large scale semiconductor manufacture are more stringent than those usually encountered. Dry air can be, and has been, produced by liquefying and regasifying air at temperatures below the required dew point, but the cost is almost prohibitive where large volumes are required.

The method used at the Youngwood plant consists of air compressors, a desiccant type dryer and a distribution system. Desiccant type dryers are manufactured by a number of companies and are available with various desiccants and methods of reactivation, although based on essentially the same principles. The most popular desiccants are silica (SIO_2), alumina ($A1_2O_3$) and zeolite crystal types. The choice will be determined by the ultimate dewpoint required, the operating pressure of the system, the relative humidity of the inlet air, the need for removing contaminants other than water, the temperature of the inlet air, and cost including post-drying filters for desiccants subject to dusting.

Equipment utilizing these desiccants will consist of two vessels where continous service is required, a method of heating the desiccant for regeneration, valving for diverting the air through either vessel and for using the air stream for removal of the absorbed moisture during regeneration and necessary temperature controls. One type of dryer recently marketed is described as "heatless" because no heat is required for regeneration—energy for reactiviation being derived from the pressure energy of the incoming air. Depending on the availability and cost of compressed air compared to costs for steam or electric heat, this dryer may present advantages over other types pri-

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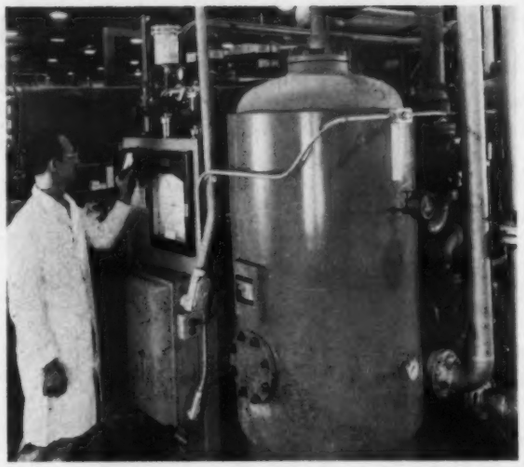

FIG. 7. AIR DRYING equipment in use at Semiconductor Department, Youngwood, Pa. Courtesy Westinghouse Electric Corp.

marily in its ability to produce low dew points. Fig. 7 shows equipment used in the dry air system at the Westinghouse Semiconductor Plant. The compressors are carbon ring, non lubricated machines chosen to eliminate the possibility of admitting oil to the drying beds. A standard type air filter is used on the inlet of these machines. In exceptionally dirty atmospheres, an air washer would be required.

The system produces air at a dew point of approximately —90°F. Humidity controls at work stations are the electronic type which employ the meaurement of dissociation current between two platinum electrodes separated by a film of phosphoric acid as the operating principle. Instruments of this type are accurate to 5 pmm ±5% and are simple and rugged. They transmit inputs to a recorder with an alarm device which sounds should the dew point rise above process specification.

Verification of the dewpoint instrumentation is performed with an Alcor Dew Pointer which relies on the cooling of the sample during rapid expansion to establish the dew point down to approximately —80°F. Below —100°F the time-honored bright cup cooled by acetone or liquid nitrogen is used for dewpoint determination.

(Continued with special section, Clean Room Literature and New Products, beginning page 40)

"DESIGN AND OPERATION OF CLEAN ROOMS, Standard Functional Criteria for", Air Force Technical Order 00-25-203, presently consisting of recommendations, not specifications, but determining operations for Air Force suppliers and their sub-contractors, is obtainable by request from the Office of the local Air Force Plant Representative (AFR) or the appropriate Air rocurement District Office (APD). Users other than AF suppliers and their sub-contractors may also apply to the Office of Technical Services, Department of Commerce, Washington 25, D. C.

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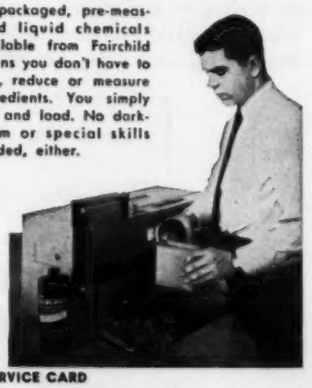

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ELIMINATE DUST/MOISTURE CONTAMINATION with STERILSHIELD by BAKER

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Acceleration tubes for Van-de-Graaff Particle Accelerators being assembled in the superclean atmosphere of Sterilshield Dust-free Workspaces at High Voltage Engineering Corp., South Bedford, Mass. The large unit in the center is a Model 1140 Sterilshield Air Cleaner, capable of servicing up to five Workspaces.

The Baker Co., world's leader in the development and production of clean-air equipment, also makes available Vacuum Ovens, portable self-contained Workspaces, and entire Prefabricated Dust-controlled Rooms. For complete information, send today for your copy of the Baker Sterilshield Catalog.

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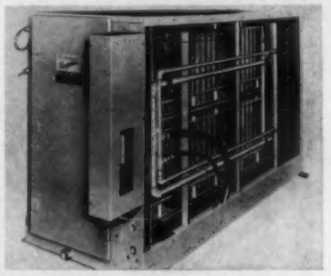
Clean Room Services and Products

Further information, or the specific literature described, is offered by the manufacturers. For a quick reply, check the corresponding number on the Reader's Service Card in this issue.

PARTICLE PRECIPITATORS



Electronic Precipitron® In-Line air cleaners are washed either manually or automatically by moving nozzle, are only 25½" deep in direction of air flow. —*Westinghouse Sturtevant Div., 220 Readville St., Hyde Park, Boston 36, Mass.*

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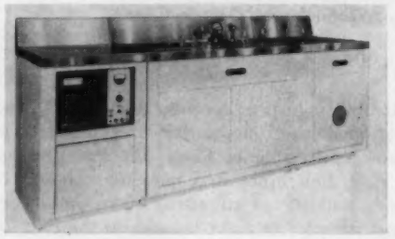
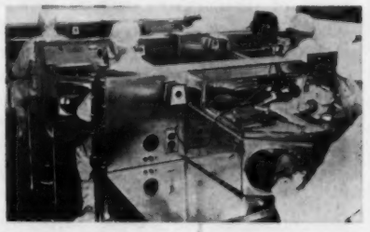
CLEAN ROOM CLEANER



Ultrasonic Cleaners designed for use in White Rooms are complete with hot and cold water, wash and rinse, recirculating pump, filter and temperature control. Also equipped with dryer and high pressure air blow-off if required.—*Circo Corporation, 51 Terminal Ave., Clark, N. J.*

CIRCLE 128 ON READER-SERVICE CARD

WORK SPACES



Dust-Free enclosures with flat plate glass tops permit use of microscopes for assembly or research operations—were developed for MIT Instrumentation Laboratory. Other enclosures for radioactive material handling and for handling dangerous biological microorganisms are available. —*S. Blickman, Inc., 536 Gregory Ave., Weehawken, N. J.*

CIRCLE 129 ON READER-SERVICE CARD

LINT-FREE CLOTHING

New acid-resistant, lint-free and anti-static herring-bone Dacron laboratory coat and overalls resist acids, chemicals, oil, dirt, grease and microorganisms, are light in weight and wash easily, are non-allergenic and opaque.—*Techni-Tool Div., 1033 Chestnut St., Philadelphia 7, Pa.*

CIRCLE 130 ON READER-SERVICE CARD

CC FILTERS

Specifying filters to meet the more sophisticated performance requirements has its frustrations. Greater sophistication breeds more complexity, especially when compounded by miniaturization within even more critical limits. Put these all together and you have filter design problems tailor-made for our engineering department. Try us.

E. G.—We produce a Low Pass Filter with less than 2% overshoot on square waves and more than 30 DB/Octave attenuation.

Write today for your portfolio of performance characteristics.

COMPONENTS CORPORATION
2855-57 N. HALSTED ST.
CHICAGO 14, ILLINOIS
EASTGATE 7-6566

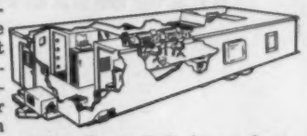
CIRCLE 41 ON READER-SERVICE CARD

GLOVE BOX

Glove Box for controlled atmosphere operations can also be used as a vacuum chamber by covering glove ports with steel plates provided.—*Delta Design, Inc., 7460 Girard Ave., LaJolla, Calif.*

FOR THIS LITERATURE CIRCLE 131 ON READER-SERVICE CARD

MOBILE CLEAN ROOM



New independent mobile Clean Room can be expanded beyond present 500 sqft facility by additional mobile units attached through air shower interlocks. Available on rental basis.—*Clean Room Div., Controlled Atmosphere Enclosures Mfg. Co., P. O. Box 5864, Jacksonville 7, Fla.*

FOR THIS LITERATURE CIRCLE 132 ON READER-SERVICE CARD

CUSTOM SYSTEMS

Environmental Control systems including dry boxes, dust shields, vacuum boxes and ovens providing 5 μ oven vacuum with less than 10 ppm water vapor are engineered to user's requirements.—*Edw. J. Greenholt, Sales Mgr., Equipment and Manufacturing Operation, Lansdale Div., Philco Corp., Lansdale, Pa.*

FOR THIS LITERATURE CIRCLE 133 ON READER-SERVICE CARD

PARTICLE DETECTOR

Airborne Particle Monitor Model 200A with dilution system provides method of accurately describing the spectrum of patricles present in air specimens from clean-room atmospheres to industrial smogs.—*Royco Instruments Inc., 440 Olive St., Palo Alto, Calif.*

FOR THIS LITERATURE CIRCLE 134 ON READER-SERVICE CARD

TRANSLUCENT PANELS

Ceiling Panels of Owens-Corning Sonofaced Fiberglas provide translucent covers to recessed light fixtures in ceiling of White Rooms, giving a smooth continuous ceiling surface without traps or crevices where dust can accumulate.—*Owens-Fiberglas Corp., Toledo 1, Ohio.*

FOR THIS LITERATURE CIRCLE 135 ON READER-SERVICE CARD

CLEANROOM "SLATES"

Marlite Panels are used in clean rooms because dust particles cannot stick to its plastic-surfaced finish. Also when a writing surface is needed for technician's notes, grease pencil is used to write directly on White Marlite wall panels, which can be wiped clean with a damp cloth. —*Marsh Wall Products, Inc., Dover, Ohio.*

FOR THIS LITERATURE CIRCLE 136 ON READER-SERVICE CARD

SMALL-PARTICLE Detector, Type CN measures particles above 1 x 10^{-2} mm radius over the range from 200 particles/cc to 10^7 particles/cc. Instrument is portable and easy to use, is described in 3-page brochure.—Gardner Associates, Inc., 408 Charles St., Scotia 2, N. Y.

FOR THIS LITERATURE CIRCLE 137 ON READER-SERVICE CARD

HEAT-LESS DRYERS, purifying systems and miniature compressors are described in a new 4-page catalog on air drying and cleaning equipment from 3 to 30 scfm capacity.—Applied Pneumatics, Inc., 740 Colfax Ave., Kenilworth, N. J.

FOR THIS LITERATURE CIRCLE 138 ON READER-SERVICE CARD

AIRBORNE-PARTICLE MONITOR for automatic, continuous analysis of airborne particulates by size and concentration from 0 to 150-million particles per cubic foot is described in 2-page Model 210 bulletin.—Royco Instruments, Inc., 440 Olive St., Palo Alto, Calif.

FOR THIS LITERATURE CIRCLE 139 ON READER-SERVICE CARD

STERILSHIELD WORKSPACES and dry boxes, prefab clean rooms, air showers, air locks, air cleaning units, ultrasonic devices, furniture and other accessory equipment are described in new 20-page brochure, "Sterilshield by Baker," —The Baker Company, Inc., 106 Granite St., Biddeford, Maine, and Chandler, Ariz.

FOR THIS LITERATURE CIRCLE 140 ON READER-SERVICE CARD

NON-LINTING CLOTHING is described in "When Success Hangs on a Thread", 8-page catalog of non-linting static-free and acid-resistant uniforms, gloves and booties for clean-room wear.—Angelica Uniform Co., 1429 Olive St., St. Louis 3, Mo.

FOR THIS LITERATURE CIRCLE 141 ON READER-SERVICE CARD

FILTERS AND CRITERIA for filter media selection are discussed in a new 8-page "Farr Filter Handbook for Electronic Equipment contains detailed charts, tables and other data necessary to size and specify filters for electronic equipment, Clean Rooms, or mobile equipment.—Farr Co., Box 90187, Airport Station, Los Angeles 45, Calif.

FOR THIS LITERATURE CIRCLE 142 ON READER-SERVICE CARD

AIR CLEANER. "A Close Look at Air-Borne Dirt," is title of booklet explaining the effectiveness of the Honeywell Electronic Air Cleaner.—Minneapolis-Honeywell, Minneapolis 8, Minn.

FOR THIS LITERATURE CIRCLE 143 ON READER-SERVICE CARD

CHAIRS for White Room with hardwood or chrome-plated steel seats and backrests are described in 2-page catalog sheet.—Adjusto Equipment Co., 515 Conneaut St., Bowling Green, Ohio.

FOR THIS LITERATURE CIRCLE 144 ON READER-SERVICE CARD

SEMICONDUCTOR PRODUCTION enclosures, including Modular Dry boxes, Life Testing Ovens and Dri-Box Bake-out systems are described in four new 2-page folders.—Forma Scientific Inc., P. O. Box 649, Marietta, Ohio.

FOR THIS LITERATURE CIRCLE 145 ON READER-SERVICE CARD

"REQUIREMENTS FOR AN ULTRA CLEAN FACILITY". 8-page brochure discusses Modular Wallpanels, Non-Dusting Materials, Illumination, Floor Covers, Air Showers, Filtration, etc.—Shielding, Inc., 514A, N. Read Ave., Riverton, N. J.

FOR THIS LITERATURE CIRCLE 146 ON READER-SERVICE CARD

"DOLLARS OUT OF THE AIR" is a new 16 page brochure K-160 describing Model C Kathabar Air Conditioning Systems and Climate Control Rooms for temperature, humidity and bacteria control.—Kathabar Air Conditioning and Drying Systems, Surface Combustion Div., of Midland-Ross Corp., 2375 Dorr St., Toledo 1, Ohio.

FOR THIS LITERATURE CIRCLE 147 ON READER-SERVICE CARD

HYDROVOID® and Microvoid® enclosures are described in 4-page folder and technical bulletins.—Air Control, Inc., 450 Narberth Ave., Narberth, Pa.

FOR THIS LITERATURE CIRCLE 148 ON READER-SERVICE CARD

COMPLETE CLEAN ROOM SERVICE, including design, pre-engineering, installation and employee training is explained in 5-page brochure and basic data form.—Controlled Environment, Inc., 52 Pickering St., Needham, Mass.

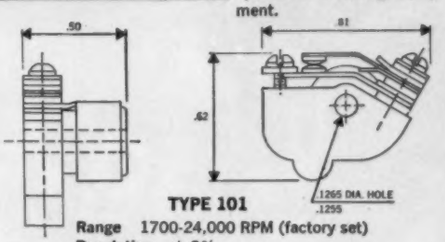
FOR THIS LITERATURE CIRCLE 149 ON READER-SERVICE CARD

DESSICANT Dryers, including Heat-Les and heat reactivated types; air particle filters, oil traps and other clean air accessories are described in series of technical bulletins.—Trinity Equipment Corporation, Cortland, N. Y.

FOR THIS LITERATURE CIRCLE 150 ON READER-SERVICE CARD

STOP THE EXECUTION, GOVERNOR!

The 101 series Governors by MOTORDYNE will stop unnecessary execution of valuable equipment. This quality unit, made of metal and non-hygroscopic materials will accurately and consistently control the speeds of rotating equipment.



TYPE 101

Range 1700-24,000 RPM (factory set)
Regulation ± 2%
Shaft size .125 (set screw retention)

Delivery two weeks.
Free literature on this and other Governors on request. Write today.

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CIRCLE 38 ON READER-SERVICE CARD

SEALED Subminiature Unimax SWITCH

TYPE EA1

Sealed against oil, water, dirt, cold, dampness, fuels, and solvents.

ELECTRICAL RATING
5 amperes 125/250 volts a-c
5 amp. 30 volts d-c resistive
2-1/2 amp. 30 v.d-c inductive

The Type EA1 environment-free switch is contained in a corrosion-resistant aluminum case, with an elastomer plunger-seal bonded to the operating pin and the case. It is furnished with wire leads of any specified length.

OVERALL SIZE
7/8" x 11/32" x 3/4"
WEIGHT: 1/2 ounce
Write today for engineering data sheet on the Unimax EA1.

UNIMAX SWITCH
Division Maxson Electronics Corporation
IVES ROAD, WALLINGFORD, CONNECTICUT

CIRCLE 39 ON READER-SERVICE CARD

Mounting of

FIG. 1. SKILLED OPERATORS team with film viewers and card-punches combined in a semi-automatic arrangement for quantity production of accurately coded mounted aperture cards.

FIG. 2. DATA FOR CARD-PUNCH operation is read directly from drawing to minimize chance of error.

The microfilming of engineering drawings is a currently accepted technique for which the Department of Defense has established an all-services standard under DOD Project EDMS-0009. In addition to the space-savings benefits to be derived from reducing storage requirements at Government installations and prime contractors, a still greater return is expected to ensue from the use of microfilmed drawings and specifications to facilitate procurement of components that in total comprise the military systems.

Accordingly, all prime contractors and their subcontractees are now required to submit their engineering drawings and specifications in roll type negative film together with a basic punched card for each frame of film. From this original negative, positive microfilm is processed for mounting into cards modified to accommodate a single frame of 35mm film. Until now, painstaking hand methods have been necessary in many operations required to ensure the accurate mounting of the correct microfilm frame in a data card bearing the corresponding drawing number and plain language interpreted description.

Microfilms in Computer Cards Mechanize Print Handling

P-M Associates, Inc. of Youngstown, Ohio, is an independent data service organization. A young organization, with equally youthful management; they provide "specialty" data processing services which their clients do not find profitable as "in-house" projects. In cooperation with the Youngstown Microfilm Company, they assisted a local steel mill in the conversion of its engineering drawing vault to microfilm. This simultaneously reduced vault space requirements by approximately 94% and afforded the mechanized retrieval and data accounting advantages of punched card techniques.

These advantages become increasingly important with plant and Air Force dispersal required in a nuclear age war. Also, by inexpensively making available microfilm copies of contractors drawings to a larger number of prospective bidders, the Air Force expects to obtain better components at lower prices.

In August 1961 P-M Associates was awarded a sizeable Air Force prime contract for the engineering vault conversion program at Wright-Patterson AFB, Dayton, Ohio. By mid-December '61 they are scheduled to process in excess of five million mounted aperture cards for delivery to the Air Force (Fig. 1).

Method Achieves Speed with Accuracy

The data recording techniques used by P-M Associates are novel in that while key-punch operators are normally trained to extract information from documents, in this information process the information

Microfilmed Drawings Streamlined

FIG. 3. SEMI-AUTOMATIC OPTICAL Mounting Device enables optical verification of aperture card with the drawing just before film is mounted in position.

FIG. 4. FINAL IBM SEQUENCING of mounted aperture cards is mechanically accomplished in card sorter, ready for incorporation into the Air Force Central Depository File.

is taken directly from the microfilmed drawing "blown" to easy-reading size on a Vue-graph screen. Depressing a foot pedal advances the next frame into viewing position, allowing the operator to retain her hands on the keyboard for uninterrupted recording (Fig. 2).

The card on which the initial recording is made is then re-recorded on a key-verifier to assure complete accuracy of the initial data pickup. This basic data card is then used to create the special deck of aperture cards in preparation for the film mounting operation. Prior to mounting the decks are fully interpreted to facilitate visual identification of the information contained in the card-punch code.

Mounting the Microfilm in Aperture Card

The same microfilm that served as the medium for the data recording is placed into the semi-automatic optical mounting device (Fig. 3). The frame of microfilm next in sequence for mounting is first flashed onto the screen to enable the operator to verify and match the drawing with the aperture card. Once this identification is established the aperture is placed into the mounting slot. Depressing a mounting button activates a die which precision-cuts the film frame and impresses it onto the adhesive perimeters of the aperture.

Sorting the Aperture Cards

After the newly mounted aperture cards are stored under pressure for twenty four hours to ensure adhesion they are passed through a IBM card sorter (Fig. 4) for final sequencing. The aperture deck and its "slave" data deck are now fully prepared for incorporation into the Air Force's Central Depository file in Dayton, Ohio.

Coming Developments in Micro-Data Techniques

The current conversion of engineering drawings and engineering specifications to micro-data form portends an imminent revolution in mass data handling and data retrieval techniques. Computer manufacturers are at this moment perfecting devices for the accommodation of microfilmed data into further reduced magnetic tape form which can afford milli-second access to vast quantities of information that can be graphically reproduced along with its descriptive data. The aperture card technique is a "first" step toward the ultimate goal of more efficient and inexpensive mass graphic data handling methods.

FOR THIS LITERATURE CIRCLE 151 ON READER-SERVICE CARD

Capacitor Reliability Search Now Over 30-Years Old

In 1930, John E. Fast, founder of the company named after him, recognized that development of the electronic industry was handicapped by inadequate reliability of key components, including capacitors. He believed that laboratory and development work was essential to attain improvement in capacitor quality and reliability.

The reasearch program at Fast did not start with a realization of the large number of factors influencing capacitor quality and reliability. Instead, the need for additional areas appeared one by one, during the course of research, and were added to the program.

Temperature vs Life. Early in 1931 data indicated that temperature had a tremendous effect on life of capacitors. Life temperature tests were then initiated that have since continued, with some capacitors withstanding elevated temperatures for periods in excess of 8 years. The curve in Fig. 1 shows the effect of temperature on life for a typical sample lot of capacitors.

Dissipation Factor. In 1930 it was believed that linen paper was the optimum paper for capacitors. However, kraft paper made from wood fibre was beginning to be used. Many said "impure, brown, etc. . . . it can't be as good as linen paper."

When Fast plotted dissipation factor against temperature (Fig. 2) the curves showed that kraft paper starts with a relatively higher dissipation factor but rises with temperature more slowly than does linen. At the higher temperatures at which capacitors normally operate, the dissipation factor of kraft paper is well below that of linen. Shortly after this discovery, linen paper disappeared from the capacitor industry.

Change of Capacity with Temperature. During World War II, the extremes of temperature to which airborne equipment was subject caused the investigation of this factor to assume prominence. A few typical Capacity-Temperature characteristic curves are shown in Fig. 3. Selection of impregnants is often determined by the ambient temperatures of the application. Arochlor 1242 (curve A) is seen as superior to Arochlor 1254 (curve B) for temperatures below 0°C, while the reverse is true for higher temperatures. Also paper-Halowax dielectric is shown to have stable capacity-temperature characteristics if higher temperatures are not required.

Other factors under continuing study by the John E. Fast research department include the effect of temperature on insulation resistance, relation of capacitor area to voltage breakdown, effect of voltage on capacitor life and the effect of temperature on leakage current.

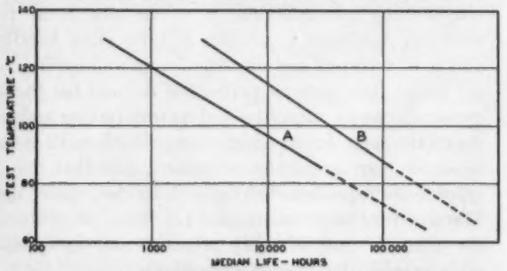

FIG. 1. TEMPERATURE vs LIFE was one of first capacitor parameters investigated. Medial Life Curve A for chlorinated dielectric paper capacity; Curve B for mineral oil paper capacitor; both tested at 150% rated voltage.

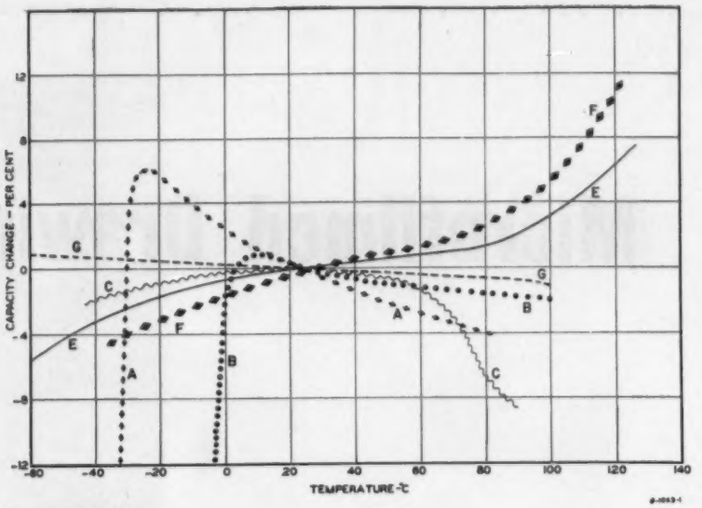

FIG. 3. CAPACITY vs TEMPERATURE characteristics for: Arochlor 1242(A), Arochlor 1254(B), Paper-Halowax (C), Paper-MylarPolyisobutylene (E) Mylar Film(F) and Polystyrene Film (G).

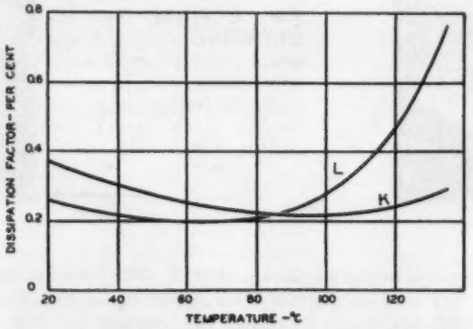

FIG. 2. DISSIPATION FACTOR vs TEMPERATURE for linen paper (L) and kraft paper (K) dielectrics.

Application of the Recomp digital computer (Fig. 4) to the definitive analyses of the wide variations which are characteristic of capacitor research data, has made possible the use of large sample lots with a corresponding increase in accuracy of the results. The continual improvement in capacitor reliability resulting from the Fast research program is demonstrated by comparative life characteristic curves of a standard type capacitor using two layers of 0.0004" paper with mineral oil impregnant tested at 600v, 85°C (Fig. 5). (*From* 14-*page Capacitor Application Data Bulletin* 60121, *John E. Fast & Co.*, 3580 *N. Elston Ave., Chicago* 18, *Ill.*)

FOR THIS LITERATURE CIRCLE 123 ON READER-SERVICE CARD

FIG. 4. RECOMP COMPUTER allows size of sampling lots to be greatly enlarged, provides almost instantaneous analysis of distribution curves for important capacitor parameters.

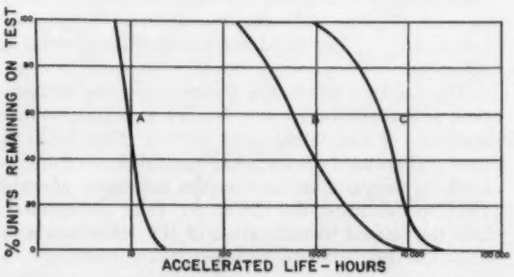

FIG. 5. IMPROVEMENT IN CAPACITOR life at 10-year intervals. Capacitors are all .0004" paper with mineral oil impregnant, tested at 600 v 85°C. Curve A-1935, Curve B-1945, Curve C-1955.

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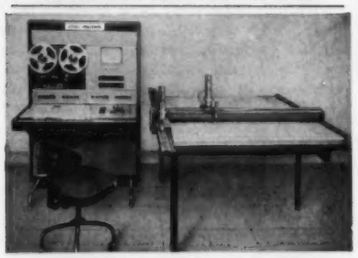
CIRCLE 42 ON READER-SERVICE CARD



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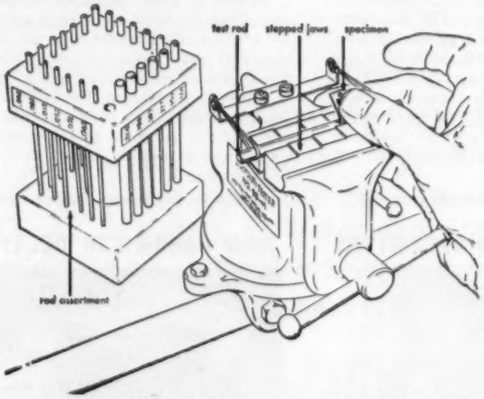
CIRCLE 43 ON READER-SERVICE CARD

Ductility of Beryllium Copper Springs

Beryllium copper is an ideal spring material having high strength and high endurance properties. It is nonmagnetic and corrosion resistant. With high electrical conductivity, low set and low drift properties it is ideal for electrical control applications. Since all internal stresses due to rolling, blanking, forming, etc., are relieved by heat treatment, the spring is left stress-free until the working load is applied.



For many applications, where all working stresses are below the elastic limit, ductility after hardening is not critical. However, if a spring requires forming, bending, peening or coining operations after hardening, ductility may become important enough to require careful control.

A practical method of determining ductility (or brittleness) of hardened beryllium copper springs is the "bend test" described below. Equipment consists of a small vise, specially machined with a V-groove to hold calibrated steel rods of various diameters (See Figure).

The spring to be tested should be flat or nearly flat for a distance at least equal to rod diameter. The spring is placed vertically in the vise between test rod and flat vise jaw. A step location is selected which will permit a 90° bend without interference. The 90° bend is made with horizontal finger motion, keeping the spring in close contact with the test rod. To pass the test, the spring must deflect 90° around the specified rod without crack or failure.

By using several test rods to find the minimum rod diameter which will not produce failure, it is possible to establish a ductility measurement for a group of springs . . . (*From 20-page catalog 11-A, Micro-Processed Springs of Beryllium Copper," Instrument Specialties Co., Inc., Little Falls, N. J.*)

FOR THIS LITERATURE CIRCLE 152 ON READER-SERVICE CARD

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by M. H. Aronson and C. F. Kezer . . . covers amplifiers, oscillators, pulse circuits, phase shifters, etc. Complete with all circuit component values and response specifications. Paper, 180 pages, 1957.

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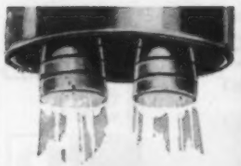

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CIRCLE 46 ON READER-SERVICE CARD

MSD new products

MICROMINIATURE CAPACITORS

New voltage stable microminiature capacitor conforming to CX Mil characteristics retains 95% of capacitance with 100v applied, 97% with 50 v applied. Capacity values from 47 to 4700 pf now available from stock will soon be extended to 0.1 μf; are rated at 100 v from —55° to 150°C.—*King Electronics, Inc., 150 Waverly Drive, Pasadena, Calif.*

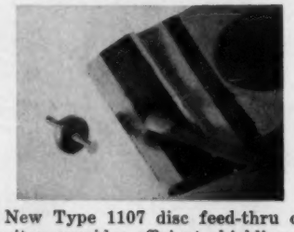
CIRCLE 153 ON READER-SERVICE CARD

SOLID TANTALUM CAPACITORS

New tan-TI-cap® solid tantalum capacitors are available in 28 new low capacitance ratings, .0047 μf through .82 μf, 20 v or 35v dc voltage ratings in smallest case size F. Other TI hermetically sealed solid tantalum polar capacitors are produced to 330 μf in larger sizes shown.—*Texas Instruments Incorporated, P. O. Box 5012, Dallas, Tex.*

CIRCLE 154 ON READER-SERVICE CARD

FEED-THRU CAPACITOR



New Type 1107 disc feed-thru capacitor provides efficient shielding of radiation in the UHF and VHF TV bands. Ceramic disc has resonant frequency higher than 1 kmc, available in capacities from 5 to 1000 $\mu\mu$f, @ 500 v dcw.—*Hi-Q Div., Aerovox Corp., Myrtle Beach, S. C.*

CIRCLE 156 ON READER-SERVICE CARD

HIGH CAPACITANCE

New CM type tantalum capacitor encompasses 8000 μf in one package 5" x 3.5" x 1". Construction of tantalum foil with tantalum oxide dielectric and a neutral electrolyte is readily adapted to custom manufacture in polar and nonpolar types and in voltage ranges from 3 to 250 volts.—*Tansitor Electronics, Inc., West Road, Bennington, Vt.*

CIRCLE 156 ON READER-SERVICE CARD

HIGH BANDWIDTH DELAYS

New NANOLINES, molded epoxy delay lines available in 10-nanosecond delay increments ranging from 20 to 100 nsec, have delay-to-rise ratios of 5 to 1 for 20 nsec units up to more than 10 to 1 for the 50 to 100 nsec units. Withstand MIL-specs in vibration, humidity and temperature cycling, have impedance of 500 ohms and attenuations of less than 0.3 db.—*Richard D. Brew and Co., Inc., Concord, N. H.*

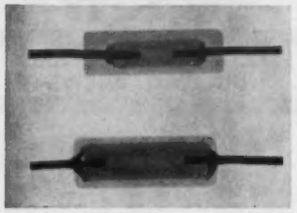
CIRCLE 157 ON READER-SERVICE CARD

R-F CHOKES

New Cambion® Series 2960 R-F Chokes, meeting or exceeding specifications of MIL-L-LT-7K, ranging in fixed inductances from 0.15 to 27.00 μh, are encapsulated in epoxy for environmental protection and mechanical stability.—*Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.*

CIRCLE 158 ON READER-SERVICE CARD

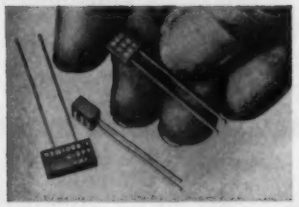
PRECISION RESISTORS



New proprietary molding technique for precision carbon and metal film resistors ensures precise stability in thermal shock tests from —60° to 365°F, lower water absorption, improved reliability and more efficient heat dissipation. Xray view shows larger core made possible.—*Key Resistor Corp., 321 West Redondo Beach Blvd., Gardena, Calif.*

CIRCLE 159 ON READER-SERVICE CARD

HIGH DENSITY WIREWOUNDS



New Type 447-P precision wirewound resistor has flat configuration with printed circuit type leads to permit high-density packaging. "Relaxed" winding method minimizes resistance drift and failures. Range: 1 ohm to 10 megohms, ⅛ watt from —65° to 125°C, derated 5%/°C over 125°C; standard tolerances to .01%.—*Kelvin Electric Company, 5907 Noble Ave., Van Nuys, Calif.*

CIRCLE 160 ON READER-SERVICE CARD

PRESSURE POT TRANSDUCER

New Model 12112 mini pot type pressure transducer is available in ranges from 1 to 200 psi, gage or absolute. Linear or non-linear outputs have conformity of 1.0% or better. Repeatability, hysteresis and friction are typically under .5%.—*Princeton Machine and Development Co., P. O. Box 187, Princeton Junction, N. J.*

CIRCLE 161 ON READER-SERVICE CARD

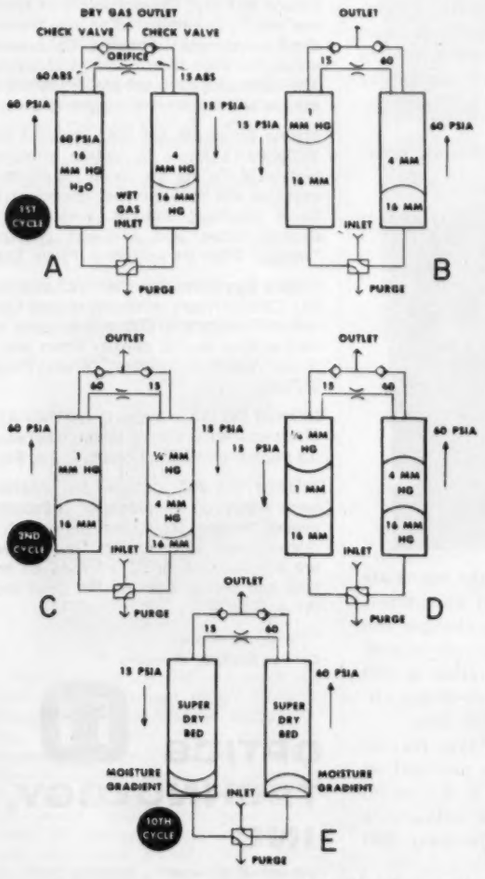
Continued on page 49

Heat-Less Air Dryer Operation

Heat-Les® Dryers utilize the tendency of desiccants to come into equilibrium with their surroundings. Instead of a relatively long cycle, during which the "used" desiccant is heated to dry it out, the Heat-Les cycle is very brief (from two to four minutes) during which time the outside air is cycled first through the left-hand chamber then through the right and chamber, at a pressure of about 60 psia.

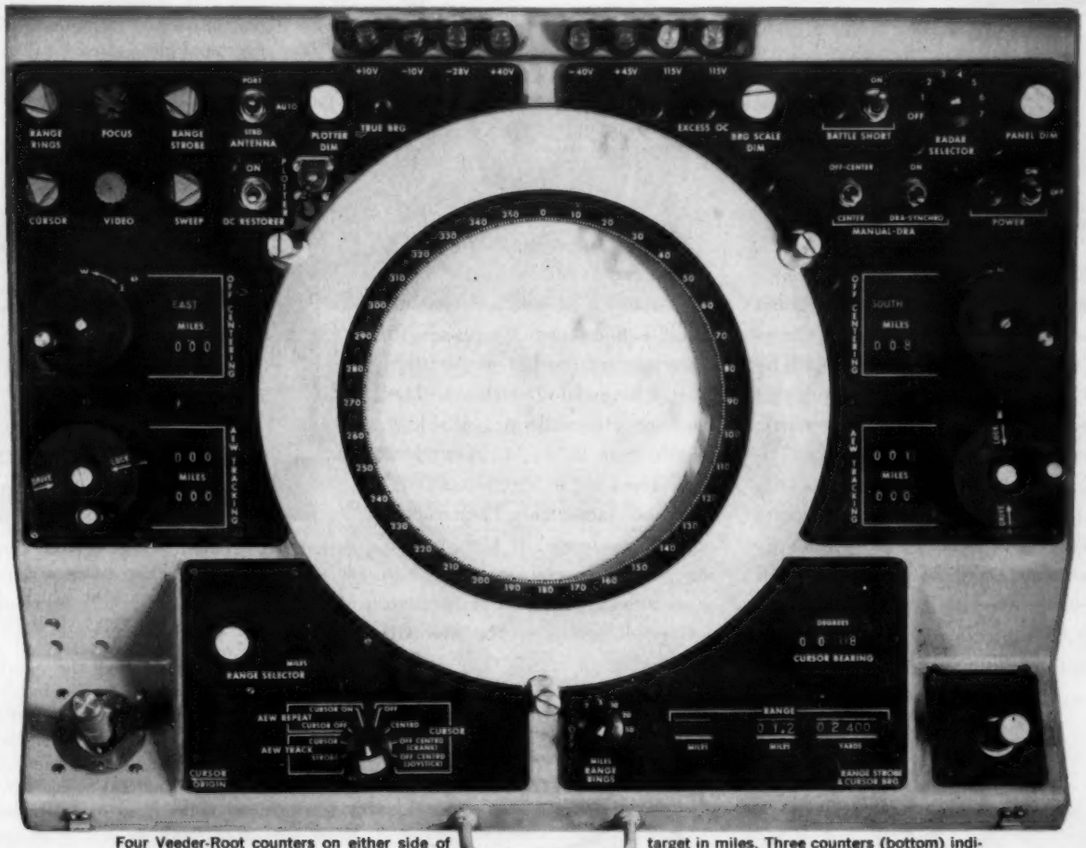
As shown in the diagrams, the reactivation of a Heat-Les Dryer progresses from initially saturated beds (represented by 16mm vapor pressure) to the conditions represented by the final illustration (E), in which the major portion of each bed is super-dry and thus capable of producing super-dry gas.

In the first illustration (A) the wet gas enters the bottom of the left-hand chamber, passing upward through the desiccant where it is dried to an extremely low dewpoint, the dry air passing through a check valve to the



Continued on page 48

What!—counters for radar reading? To give the Navy vital facts fast, Philco builds counters right into radar control panels. These direct readout counters were designed by Veeder-Root to eliminate dials and manual interpretation of instrument data—make radar reading easier than ever. Find out how Veeder-Root can help you simplify your operations. Write to Instrument Section, Veeder-Root Inc., Hartford 2, Conn. **count on . . . VEEDER-ROOT**



Four Veeder-Root counters on either side of screen tell radar operator exact location of target in miles. Three counters (bottom) indicate angle and range in miles and yards.

CIRCLE 47 ON READER-SERVICE CARD

You can put ½ TON on this slide

New Heavy-Duty Slide from Chassis-Trak

Now you can rack-mount your heaviest electronic gear, yet keep it readily accessible for checking and servicing. A new heavy-duty Circulating Ball Slide, developed by Chassis-Trak, will easily support equipment in the 1000 lb. range, *even under extreme shock and vibration conditions.* Secret of the slide's strength is its Circulating Ball design *(see phantom view above).* Weight is distributed evenly over the balls which rotate in the direction of the pull, resulting in easy sliding action.

The new Circulating Ball Slide is permanently dry-lubricated with Poxylube 75, a bonded molybdenum disulfide film which assures smooth operation for the life of the slide. Easily assembled with standard hardware, the slide is available in lengths from 16″ to 24″ in two-inch increments and in lengths up to 60″ in six-inch increments. Each track is only 1⅝″ wide and 3″ high, requiring much less chassis space than other slides in this heavy-duty range.

Get full details on the new CB Slide today.

for further information contact:

525 South Webster Ave., Indianapolis, Indiana

chassis Trak inc.

CIRCLE 48 ON READER-SERVICE CARD

dry air outlet. Simultaneously, a small percentage of the dry gas is expanded through the orifice between the chambers, and flows down through the right-hand chamber, reactivating that desiccant, and passing out through the purge exhaust. After approximately one minute this phase ends, the chambers are automatically reversed, the right-hand chamber serving as the drying medium, while the left-hand chamber is being reactivated, as shown in the second phase illustration (B) of the first cycle.

Since no heat is used, maintenance usually associated with the heater elements is eliminated. Also desiccant life and efficiency is increased through the elimination of oil-varnishes forming on surfaces of desiccant particles. The Heat-Les Dryer has a normal tendency to reject oil which enters with the incoming gas. While complete oil elimination is not always positive, many users have completely solved their oil problem by proper application of a Heat-Les Dryer . . . (*From 6-page bulletin HA-308, Heat-Les Dryers, Trinity Equipment Corporation, Cortland, N. Y.*)

FOR THIS LITERATURE CIRCLE 162 ON READER-SERVICE CARD

Decimal Indicator

New 500 Series Decimal Indicator provides a high-reliability in-line decimal display from static binary-coded-decimal high impedance data. Available in from 3 to 6 digits, projection techniques are used to present the data on ground glass screens so that the numerals or other symbols appear in one plane. The type 503 Indicator is pictured.

An input signal of —1 volt into 10 Kilohms, is required. Total power is only 0.1 mv. Since the inputs are dc coupled, the data rise times are not of importance. The maximum useful rate at which data changes can be followed by the human eye is 20 changes per second. The maximum recommended rate of operation is 100 changes per second, although the internal electronic circuitry is capable of responding to faster input data.

Additional low-current circuits, such as relays, may be driven from decimal outputs which can be provided on customer's request. The output capability is 5 v at 50 ma into 100 ohms. The 500 Series Decimal Indicator is a development of the *Howard Instrument Company,* 208 *River Ave., Red Bank, N. J.*

FOR THIS LITERATURE CIRCLE 163 ON READER-SERVICE CARD

WAVELENGTH REJECTION FROM X-BAND TO X-RAY

MONO PASS

INTERFERENCE FILTER SETS

Optics Technology offers filter sets covering the range of 400 millimicrons to 1.75 microns to meet your requirements in spectral analysis. These MONOPASS interference filter designs reject from X-band to X-ray! The possibility of spurious results is eliminated as only the desired wavelength is passed. Calibration curves for each filter pinpoint accuracy. The curves for each set are laminated in plastic and bound in a rugged volume.

Visible Spectrum Set 10A* includes ten MONOPASS filters to isolate principal lines as K, Ca, Hg, etc., from 706 millimicrons to 404 millimicrons, important in flame chemical analysis. Four neutral density filters and a linear spectral "wedge" filter are included. Price, $325.

Visible Spectrum Set 12A* includes ten MONOPASS filters uniformly spaced from 400 millimicrons to 700 millimicrons, as well as four neutral density filters and a linear spectral "wedge" filter. Price, $325.00.

Infrared Set 15A includes ten MONOPASS filters spaced at every 0.1 micron between 0.8 micron and 1.75 microns. Price, $450.

Infrared Set 20A includes ten interference filters on 1″ diameter substrates spaced at every 0.1 micron between 1.75 microns and 2.75 microns. These filters are blocked out to 3.2 microns on the long end and to X-ray on the short end. Price, $450.00.

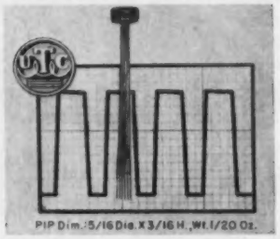
**Distributed through Central Scientific Company*

OPTICS TECHNOLOGY, INC

248 Harbor Boulevard • Belmont, California
LYtell 1-0358 (Area Code 415)

CIRCLE 49 ON READER-SERVICE CARD

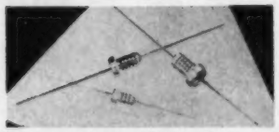
SUBMIN PULSE TRANSFORMER



New PIP series transistor pulse transformers designed for physical compatibility with transistors have ratio of 4.4:1, pulse width of .05 to 10 μsec, rise time of .018 to .4 μsec, and output impedance of 200 ohms. Meet MIL-T-21038.—*United Transformer Corp.*, 150 *Varick St., New York* 13, *N. Y.*

CIRCLE 164 ON READER-SERVICE CARD

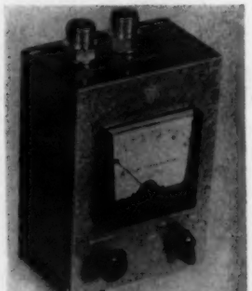
TANTALUM CAPACITORS



New "Top Hat" capacitors, type TZ for operation from —55° to 85°C, and type TZH for operation to 125°C are sintered anode liquid electrolyte types giving exceptional resistance to MIL environments and high stability in low temperature ranges. Capacities range from 1.7 μf to 330 μf at 6-126 v (TZ), or 4-85 v dc (TZH).—*Cornell-Dublier Electronics Div., Federal Pacific Electric Co.*, 50 *Paris St., Newark* 1, *N. J.*

CIRCLE 165 ON READER-SERVICE CARD

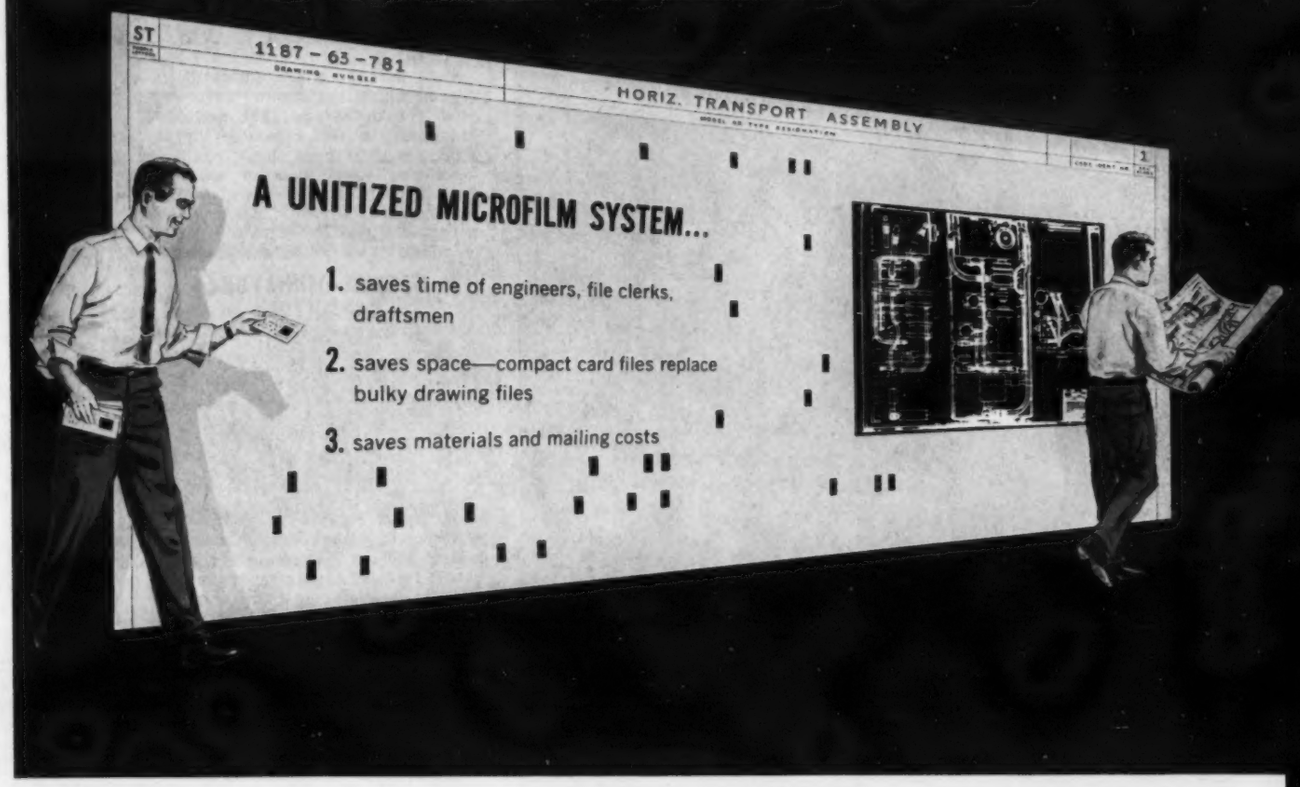
SQUIB TESTER



Vulnerability to RF currents of squibs in missile and rocket systems is measured by new squib testing device. Sensing element and circuit do not come in contact with firing circuit. Missile squib harness is detached from the squib and plugged into the instrument squib connection which reads RF energy picked up by harness.—*KeXplore Electronics, Inc., P. O. Box* 22084, *Houston, Texas.*

CIRCLE 166 ON READER-SERVICE CARD

Here's a better, more practical way to reproduce engineering drawings


ST
1187 - 63 - 781
DRAWING NUMBER
HORIZ. TRANSPORT ASSEMBLY
A UNITIZED MICROFILM SYSTEM...
1. saves time of engineers, file clerks, draftsmen
2. saves space—compact card files replace bulky drawing files
3. saves materials and mailing costs

Turn out high-quality prints on ordinary paper by xerography!

The benefits of a unitized microfilm system begin at the drafting board and spread throughout a company to save time, materials, and space.

1. Important savings result from more productive use of engineers' time . . . no costly waiting for prints. **2. Sizeable reductions** in materials and mailing costs provide further savings. **3. All drafting can be done in pencil** on plain white paper . . . no inking on expensive vellum or linen

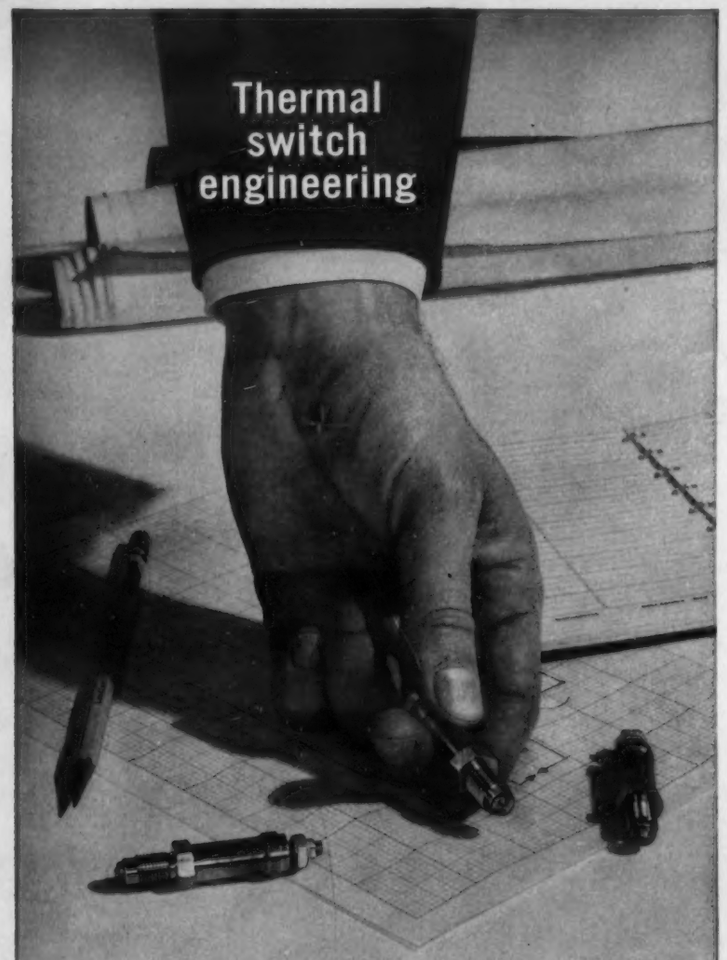
A unitized microfilm system has three basic steps: microfilming original drawings or changes; mounting the individual microfilm frames into die-cut apertures of data-processing cards; and, from the cards, automatically enlarging the microfilmed drawings into workable size by a xerographic printer.

Dry, positive, reduced-size prints *on ordinary paper*—easy to read and easy to handle—emerge in seconds, ready for immediate use. There is no refiling. The quality of xerographic prints is superb, yet they are so inexpensive, engineers may discard them after use.

Unitized microfilm systems offer many other striking economies. Our booklet on benefits is yours for the asking. Write Xerox Corporation (formerly Haloid Xerox Inc.) 61-203X Haloid Street, Rochester 3, N. Y. Branch offices in principal U.S. and Canadian cities. *Overseas:* Rank-Xerox Ltd., London.

CIRCLE 50 ON READER-SERVICE CARD

XEROX CORPORATION



"TIP TEMPERATURE" RESPONSE SWITCH FROM CPI RESEARCH

This is a new precision thermal switch designed to act as a warning device in controlling temperatures in aircraft generators. But that is only part of the story. This CPI switch responds to tip temperatures rather than shell temperatures. For that reason it's called the "Tip-Stat". It now joins the growing CPI family of high quality, custom, precision thermal switches.

There's a good chance that this switch or a modification of it can solve your thermal control problems. If not, CPI engineers can create a new switch that does. In either event, why not tell us about your thermal control problem now?

This hermetically sealed switch has spring loaded inner cartridge, can be "bottomed" in hole under considerable tip pressure; calibration range is −20F to 550F; safe momentary overshoot to 600F; reaction time, less than 0.5 seconds. Mention "Tip-Stat" when inquiring.

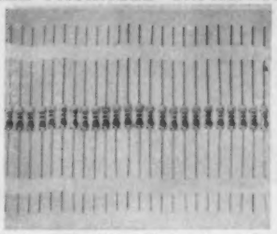
CPI

CONTROL PRODUCTS, INC.

274 Ridgedale Ave., Hanover, N. J.

CIRCLE 51 ON READER-SERVICE CARD

REEL PACKAGED CAPACITORS



Reel packaging for automatic insertion machines is now being supplied for their type 7301 and 7302 axial lead tubular capacitors by the Hi-Q Division to fit the U. S. Shoe Machinery Corp. insertion machines for automatic printed circuit board assembly.—*HiQ Division, Aerovox Corporation, Myrtle Beach, S. C.*

CIRCLE 167 ON READER-SERVICE CARD

SPECIAL MINIATURE CAPACITORS

Special ¼" long Cerafil Capacitors in 1 to 1000 uuf capacities are available in lacquer, durez or epoxy molded coatings depending on diameter or test requirements. Lacquer coated units are only .060" max diameter and are intended for potted circuit applications or for circiuts where no severe humidity, shock or vibrational conditions exist. Up to 100v dcw ratings are possible.—*Hi-Q Div., Aerovox Corporation, Olean, N. Y.*

CIRCLE 168 ON READER-SERVICE CARD

POLYSTYRENE CAPACITORS

New polystyrene dielectric capacitors in ranges from .01 to 1.0 μf have an operating temperature from −55° to 85°C, with a resistance of 500,000 megohm microfarads when measured at 25°C. Besides Style "A" shown, Style "B" with single lead and grounded case and Style "C" with double lead on one end are available. —*Electronics Div., Airborne Accessories Corp.,* 1414 *Chestnut Ave., Hillside* 5, *N. J.*

CIRCLE 169 ON READER-SERVICE CARD

Continued on page 51

Large, Adjustable Capacitors

In applications such as the operational amplifier (integrator) of an analog computer it is vitally important that the bridge capacitors match each other to within a very close tolerance. The initial capacity value of these capacitors also must be within a closer tolerance than is available in standard types of capacitors.

In response to demands by analog computer designers, Mr. Norman Schwartz, Chief Engineer of Southern Electronics Corporation, Burbank, Calif., invented the Polystyrene Adjustable Capacitor (Fig. 1) to meet this need for adjustable, highly stable capacitors in the .001 to 10 μf range. It also is being used as a standard for comparison bridges where highly accurate capacitors are being tested.

The capacity of any SEC Polystyrene Adjustable capacitor can be adjusted over a ±1½% range of the rated value, and is therefore capable of producing a capacitance match as close to absolute as possible. The stability of a Polystyrene Adjustable Capacitor is such that they are regularly used as standards in the SEC laboratory and as such are periodically sent to the National Bureau of Standards for calibration. Over the years, since 1952, they have not drifted more than .05%.

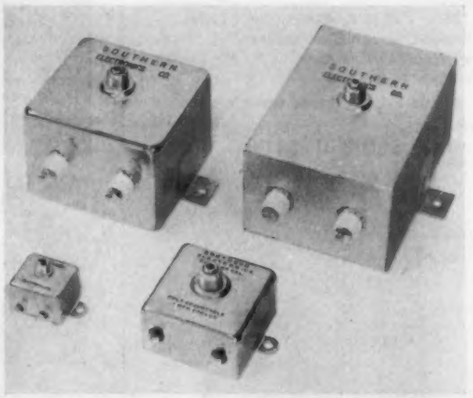
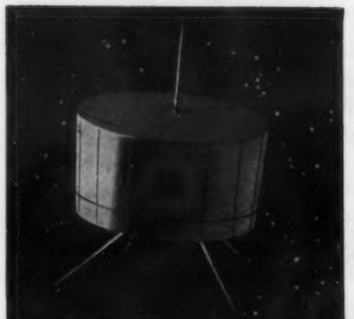


FIG. 1. **ADJUSTABLE** Polystyrene Capacitors withstanding up to 400 v dc working potentials are available in standard sizes from .001 to 10 μf.

Hermetically sealed Polystyrene Adjustable Capacitors are rated for working voltages up to 400 v dc over ambient temperatures from −55° to 60°C. Maximum dielectric absorption is 0.02%. Typical Dissipation Factor plotted against ambient temperature is shown



GOERZ OPTICS SERVE THE ROCKET AND MISSILE INDUSTRY

Whatever your optical needs—Tracking — Reconnaissance — Plotting — Photo Interpretation — Mapping — the uniformly high quality of GOERZ lenses is your guarantee for reliable performance.

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INWOOD 96, L. I., N. Y.

CIRCLE 52 ON READER-SERVICE CARD

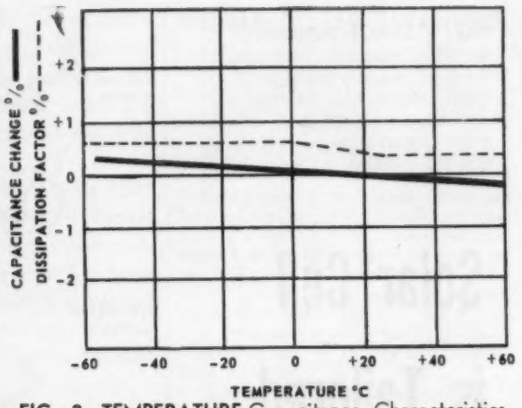


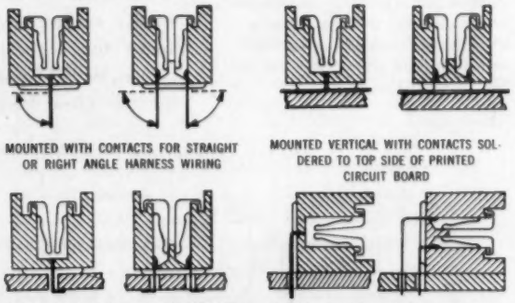
FIG. 2. TEMPERATURE-Capacitance Characteristics and Dissipation Factor of Adjustable Polystyrene Capacitors are shown.

in Fig. 2. Temperature Coefficient is —100 ppm/°C. Capacity adjustments are made by inserting an Allen wrench in the screw hole in the center of the top face of the capacitor case.

FOR MORE INFORMATION CIRCLE 170 ON READER-SERVICE CARD

New Printed Circuit Connectors Feature Reliability

The printed circuit connector plays a vitally important part in the increasingly complex circuitry and wiring of electronic equipment. The fate of a multi-million dollar missile may rest on the proper functioning of your printed circuit connector.



MOUNTED WITH CONTACTS FOR STRAIGHT OR RIGHT ANGLE HARNESS WIRING

MOUNTED VERTICAL WITH CONTACTS SOLDERED TO TOP SIDE OF PRINTED CIRCUIT BOARD

MOUNTED VERTICAL WITH CONTACTS FOR DIP SOLDERING TO UNDERSIDE OF PRINTED CIRCUIT BOARD

MOUNTED AT RIGHT ANGLE WITH CONTACTS FOR DIP SOLDERING TO UNDERSIDE OF PRINTED CIRCUIT BOARD

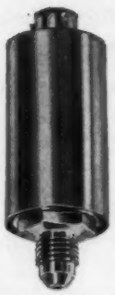
Masterite's printed circuit connectors accommodate .054 to .071 printed circuit cards, 6 to 130 contacts in both single and double row; with double row construction allowing use of both sides of the circuit card or for redundant circuits. Military and industrial designers have worked closely with the manufacturer in the development of a choice of contacts, mounting styles (see Figure) and inset materials. All Masterite printed circuit connectors meet or exceed MIL-C-21097.

Glass-filled diallyl phthalate insert material has high insulating characteristics with voltage breakdown at sea level of 2500 v rms and 600 v rms at 60,000 ft.

. . . (*From 20-page Connector catalog, Masterite Industries Div., Houston Fearless Corporation, 835 West Olive St., Inglewood, Calif.*)

FOR THIS LITERATURE CIRCLE 171 ON READER-SERVICE CARD

A Transducer Two Years Ahead of its Time



A completely new patented pressure sensor concept has been utilized in Servonic's new, low pressure L-96 Transducer. This miniature potentiometer-type unit withstands vibration levels in excess of 35 g's with less than 1% error. Two separate sets of aneroid capsules attached to opposite ends of a driving frame are utilized in the design. One set senses the driving media while the second can be evacuated for an absolute pressure reference, or vented to the atmosphere for gage measurement.

Pressure changes are transmitted through a unique, frictionless, metallic belt linkage system to position the wiper of the precision potentiometer. The fluid filled interior dampens vibration effect, provides long life and minimizes electrical noise. The unit is so insensitive to vibrations, extended dwells are allowed at any vibration frequency. Besides its excellent vibration characteristics, the L-96 has a temperature range of —65° to 275° F and a range of 0-15 to 0-350 psia or g.

For additional information about the wide pressure ranges and mounting configurations available in the L-96, write:

SERVONIC INSTRUMENTS, INC.
Manufacturers of pressure transducers, pressure switches, rectilinear potentiometers and slip ring assemblies.
1644 WHITTIER AVENUE, COSTA MESA, CALIFORNIA

CIRCLE 53 ON READER-SERVICE CARD

CIRCLE SEAL PRECISION VALVES
precision valves
... the valve that is guaranteed not to leak!

Design and application experience gained in developing and manufacturing truly leakproof valves has enabled Circle Seal to earn and retain its position of leadership. Advanced design concepts based upon extensive experience and investigation make Circle Seal valves the ultimate in quality and reliability. These time-proven concepts, incorporated in the valves below are designed to help you select the *right* valve for your specific application.

CIRCLE SEAL VALVES FOR AIRCRAFT, MISSILE AND GROUND SUPPORT REQUIREMENTS

	Aircraft								Missiles & Rockets								Ground Support					
	Fuel	Pneumatics	Hydraulics	Purge & Inerting	Oxygen	Water & Alcohol	Lubricating Oil	Fuel	Oxidizer	Pneumatic Control	Hydraulic Control	Cryogenics	Electronics	Packaging	Control Panels	Inerting System	Hydraulic Control	Pneumatic Control	Fuel Handling	TYPICAL VALVE TYPES STANDARD	SPECIAL
Automatic Drain	●		●					●													P7-526, P19-526
Bleed, Manual		●	●	●	●					●			●				●				P12-228, P4-416
Check, Low Pressure	●	●	●	●	●	●	●	●	●	●	●	●			●	●	●	●	●	800	P6-620, P3-319
Check, High Pressure	●	●	●	●	●		●	●	●	●	●	●			●	●	●	●	●	200/2100/2600	
Check, Restricter	●	●	●				●	●	●	●	●	●			●		●				P-649, P9-649
Check, Modulor	●	●	●		●	●	●	●	●	●	●	●					●				P1-278, P5-356
Check, Vent Port	●	●	●					●	●	●	●				●	●	●	●	●		P4-673, P-698
Check – Relief	●		●				●	●	●		●	●									P-389 types
Checkout, System								●	●	●	●						●	●	●		P1-425, P2-425
Drain, Automatic	●			●		●		●	●			●			●				●		P7-526, P19-526
Drain, Manual		●	●				●												●	9200	P-394, P-427
Filter		●	●	●						●									●		P4-308, P4-691
Fill & Bleed			●	●						●	●			●							P20-228, P1-427
Gauge Protector															●					1100	
Relief, Low Pressure		●	●	●		●	●	●	●	●	●	●	●	●	●				●	500	P12-352, P4-637
Relief, High Press.	●							●	●			●			●		●		●	5100	
Relief, Modulor			●				●	●	●			●	●				●		●		P4-648, P7-349
Relief, Thermal	●		●	●		●	●	●	●			●	●	●	●	●	●		●		P12-352, P27-220
Relief, Vacuum	●		●	●			●	●	●			●	●	●			●		●		P-262, P2-534
Selector, Manual						●	●								●						P7-418, P48-395
Shut-off, Manual, H.P.		●	●	●	●		●			●	●				●	●	●			900	P15-350, P6-405
Shut-off, Manual, L.P.		●	●	●	●	●	●			●	●		●		●	●	●	●		9200	P3-395, P45-395
Shut-off, Vacuum		●		●						●			●		●	●		●		9200	P3-395, P45-395
Shuttle	●	●			●			●	●	●	●	●	●		●		●	●	●	400	P-652, P-702
Vacuum Breaker	●		●	●			●	●	●			●	●				●		●		P-262, P2-534
Vent & Breather	●		●	●			●					●		●			●		●		P-249/P-262, P5-308
Vent, Float Actuated	●																				P-401, P5-401

Typical standard lines of off-the-shelf type valves based upon proven Circle Seal design concepts are shown below:

200 SERIES CHECK VALVE

The one perfect answer for virtually any check valve requirement.
- Zero leakage, 0-3000 psi
- Low cracking pressure
- Adaptable to most fluids
- Unequalled reliability

Technical Data Form #35-2044R

2100 SERIES CHECK VALVE

Advanced check valve design utilizing the proven Circle Seal Principles in high pressure pneumatic systems.
- Zero leakage, 0-3000 psi
- Exceptional durability
- Designed to withstand surge flows
- Compact, light-weight

Technical Data Form #35-2283

2600 SERIES CHECK VALVE

Precision check valve performance in minimum package size.
- Versatile pressure range, 0-3000 psi
- Minimum size and weight
- Suitable for any mounting position
- Maintenance free reliability

Technical Data Form #35-2284

800 SERIES CHECK VALVE

The one perfect answer for applications requiring a combination of low pressure drop and zero leakage.
- Zero leakage, 0-600 psi
- Low cracking pressure, low pressure drop
- Suitable for any mounting position
- Not affected by "O" Ring swell

Technical Data Form #35-2046R

400 SERIES SHUTTLE VALVE

The ultimate in automatic circuit switchover for low pressure and high pressure liquid and gas systems.
- Minimum interflow
- Very low shuttling pressure
- No cross-port leakage
- Absolute reliability – accurate shuttle response

Technical Data Form #35-2242

500 SERIES RELIEF VALVE

A precise reliable combination of small size and full flow capacity.
- Zero leakage virtually to cracking pressure
- Reseat dead tight, close to cracking pressure
- Opens freely without sticking
- Maximum flow – minimum size

Technical Data Form #35-2145R

5100 SERIES RELIEF VALVE

Combines the simplicity of direct actuation with accurate reliable performance in virtually any gas or liquid service.
- Adjustability for precise setting
- Zero leakage at normal system pressures
- Smooth, chatter-free operation
- Minimum hysteresis

Technical Data Form #35-2118R

900 SERIES SHUT-OFF VALVE

The one perfect answer for system shutoff where leakage cannot be tolerated.
- Zero leakage, 0-6000 psi with gas or liquid
- Metered opening to protect system
- Low operating torque
- Maintenance-free operation

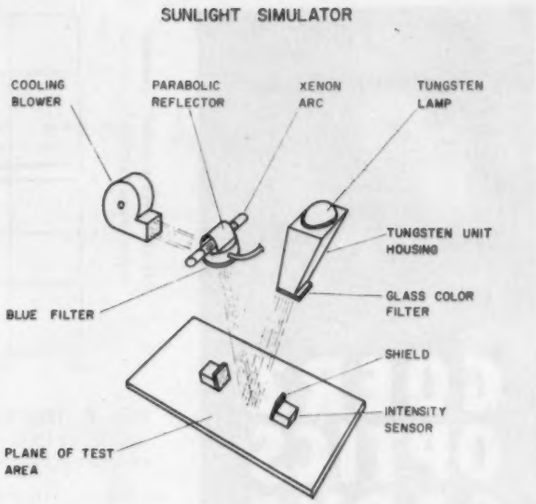
Technical Data Form #35-2238

CIRCLE SEAL precision valves

JAMES, POND & CLARK, INC.
2181 East Foothill Boulevard
Pasadena, California

CIRCLE 54 ON READER-SERVICE CARD

FIG. 1. SPACE SUNLIGHT simulator mixes the blue-rich light of Xenon lamp with high-temperature incandescent lamp to produce an energy spectrum equivalent sunlight in outer space.

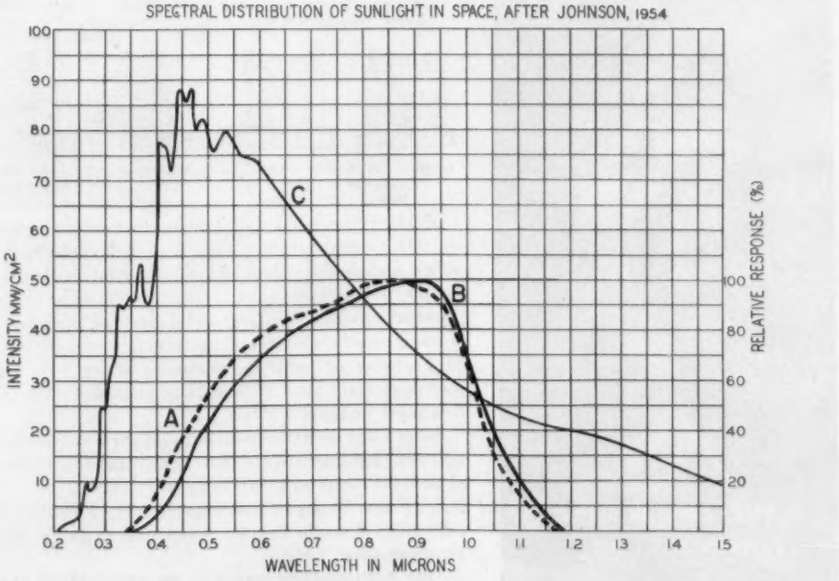


Solar Cell is Tailored to Blue Space

FIG. 2. "BLUE SPACE" SOLAR CELL response curve (A), is compared to response curve of standard Hoffman solar cell (B), both selected at random. Analysis of sunlight in space is shown by curve (C) after Johnson.

The development of a new light source to accurately simulate the sunlight of "blue space", beyond earth-bound atmospheres, was a necessary step in the refinement of solar cells for furnishing satellite power. Research with this source at the Hoffman Semiconductor Center, El Monte, Calif., has produced a solar cell having improved conversion efficiency in the sunlight of outer space.

The energy composition of sunlight in far space is considerably different from that which reaches the earth's surface, even at midday on the equator. In space the highest energy content lies in the 0.4μ region, or blue portion of the spectrum. As the wavelengths grow longer, there is a gradual decline in



energy. However, as sunlight penetrates the air, water vapor and other air contaminants, many of the shorter wavelengths are filtered out, making the sunlight near earth much redder. At sunrise and sunset, when the sunlight travels the longest path through air, the reds predominate.

The sun simulator (Fig. 1) blends blueish light from a Xenon lamp and reddish light from a Tungsten lamp to produce an artificial light closely resembling sunlight in outer space. This light has been used to experimentially confirm a theory advanced by Hoffman scientists that solar cells having a thinner top layer of active material would make more efficient use of the blue light.

The new Hoffman Blue Space cell is the result, having a response in percent of output shown by line A in Fig. 2. In comparison is the output curve for a standard Hoffman Solar cell, labelled B. The energy analysis of sunlight in outer space is shown by curve C, which shows that still more efficient utilization of the sun's energy may result from this line of research. This means that smaller solar power units could power space craft, saving more space and weight for "payload." Another dividend gained from the use of a thinner active layer is that the Blue Space cell is less susceptible to "Van Allen belt" radiation.

FOR THIS LITERATURE CIRCLE 172 ON READER-SERVICE CARD

BOOK REVIEWS

BASIC PHYSICS OF THE SOLAR SYSTEM, by V. M. Blanco and S. M. McCuskey, (1961), Addison-Wesley Publishing Co., Inc., Reading, Mass., 310 p., 6″ x 9″, $7.50. Provides reader having math background equivalent to two years of engineering with working knowledge of astronomical coordinates and elementary celestial mechanics.

FOR MORE INFORMATION CIRCLE 173 ON READER-SERVICE CARD

ELECTROMECHANICAL COMPONENTS FOR SERVOMECHANISMS, by Sidney A. Davis and Byron K. Ledgerwood, McGraw-Hill Book Co., 330 West 42nd St., New York 36, N. Y. 338 p., 7″ x 9″, $11.50. Potentiometers, synchros, induction potentiometers and resolvers, tachometers and ac and dc servomotors are completely explained.

FOR MORE INFORMATION CIRCLE 174 ON READER-SERVICE CARD

ADVANCES IN THE ASTRONAUTICAL SCIENCES, Vol. VI, by Horace Jacobs & Eric Burgess, Editors, (1961) The Macmillan Co., 60 Fifth Ave., New York 11, N. Y., 898 p., 6½″ x 10″, $25.00. Fifty-seven research papers given at the 1960 Annual meeting of the American Astronautical Society include space communications, propulsion, guidance and control, flight mechanics, vehicle design re-entry problems and astronautical systems.

FOR MORE INFORMATION CIRCLE 175 ON READER-SERVICE CARD

WELDABLE LEAD CAPACITORS

Gold-plated Dumet leads which are both solderable and weldable are now standard on All "VK" Axial ceramic capacitors in values from 10 pf to .01 μf, and are available on all Axial "VY" porcelain capacitors including those made from the new #155 Frit and conforming to MIL-C-11272B.—*Vitramon, Inc., P. O. Box 544, Bridgeport 1, Conn.*

CIRCLE 176 ON READER-SERVICE CARD

WAFER CAPACITOR

New capacitor constructed with interleaving copper foil, Amplifilm® dielectric and a low-loss bonding resin in available in capacitance ranges from 100 μμf to 0.1 μf ±10% and in working voltages from 4 kv to 15 kv dc. Minimum size as small as 1⅛″ x 1⅛″ x ¼″.—*Capitron Div., AMP Incorporated, Elizabethtown, Pa.*

CIRCLE 177 ON READER-SERVICE CARD

SOLID-STATE DELAY RELAYS

Externally adjustable solid-state time delay relays available in timing periods up to 15 minutes have adjustment ranges of 100-1 in the low time periods and 10-1 in high time periods. Both static output and relay output versions meeting MIL-specs are available.—*Autronics Corporation, 180 No. Vinedo Ave., Pasadena, Calif.*

CIRCLE 178 ON READER-SERVICE CARD

NEW
B
BREW
NANOLINE
HIGH BANDWIDTH
DELAY NETWORKS
IMMEDIATE
DELIVERY
OF SAMPLES
PRODUCTION
QUANTITIES
IN 4 WEEKS
OR SOONER
THESE NEWLY DEVELOPED HIGH PERFORMANCE UNITS ARE AVAILABLE IN 20 TO 100 NANOSECOND DELAYS WITH FAST RISE TIME
DELAY N SEC. | Tr | DELAY N SEC. | Tr | DELAY N SEC. | Tr
20 | 5/1 | 50 | 10/1 | 80 | 10/1
30 | 6/1 | 60 | 10/1 | 90 | 10/1
40 | 7/1 | 70 | 10/1 | 100 | 10/1
Impedance 500 ohms
Delay tolerance ± 10%
Attenuation 0.3 DB max.
Epoxy Encapsulation
Leads or terminals
Size: 2¼ X .300 X 1″
OTHER NEW DESIGNS BY BREW
LUMPED - DISTRIBUTED CONSTANT
QUARTZ AND BARIUM
OPTICAL DELAY LINES
New Brochure
of Brew products & facilities
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BREW SALES REPRESENTATIVES:
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RICHARD D. BREW and Company, Inc.
Concord, N. H.

CIRCLE 55 ON READER-SERVICE CARD

SLIP-RINGS
and
ROTARY SWITCHING
ASSEMBLIES

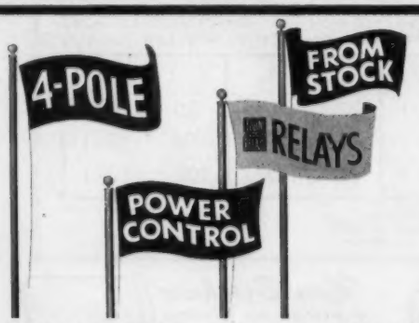
designed and built to your performance specifications

- Single-circuit or multi-circuit
- Low-current or high-current
- Drum-type or pancake
- Internal or external rings
- Continuous or segmented

Bulletin 61-01 gives details of representative Electro Switch slip-ring designs and includes a convenient check-list for your use in specifying slip-rings and rotary switching and selector assemblies. Write today for your free copy.

ELECTRO SWITCH
SLIP-RING DIVISION CORP. Osterville, Massachusetts

CIRCLE 56 ON READER-SERVICE CARD



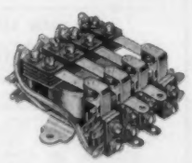
4-POLE POWER CONTROL RELAYS FROM STOCK

Elgin Advance stocks the only 4-pole power control relay of this type on the market. Specify the PC Series when you require dependable current switching.

The PC Series features heavy load carrying capacity, combined with small size — a variety of contact arrangements — and a wide range of AC and DC coil voltages and resistances.

SPECIFICATIONS

Contact arrangements — SPDT, DPDT, 3PDT, 4PDT
Contact rating — 15 amps resistive, 5 amps inductive
Contact material — 0.25" dia fine silver
Coil voltages & resistances — wide range of AC and DC
AC power — 10-12 VA, nominal
DC power — 2-3 watts, nominal
Dimensions — 1.906" x 3.062" x 2.593", maximum
Weight — 8 ounces, maximum



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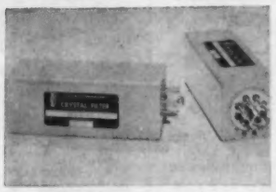
ELGIN advance RELAYS ELGIN ADVANCE RELAYS
THE ELECTRONICS DIVISION OF ELGIN NATIONAL WATCH COMPANY
2435 NORTH NAOMI STREET, BURBANK, CALIFORNIA

CIRCLE 57 ON READER-SERVICE CARD

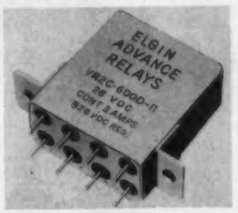
MATCHED SSB FILTERS



Matched pairs of precision single sideband filters for use in voice communications SSB transmitters and receivers provide upper and lower-sideband filtering for 1400 kc carrier frequency with a 3 db bandwidth of 2.5 kc (0.4 to 2.9kc from carrier freqeuncy). Carrier rejection is 20 db and undesired sideband rejection at least 50 db. Impedance is 10 kilohms, insertion loss is less than 6 db.—*Filter Dept., Systems, Inc., Box 7726, Orlando, Fla.*

CIRCLE 179 ON READER-SERVICE CARD

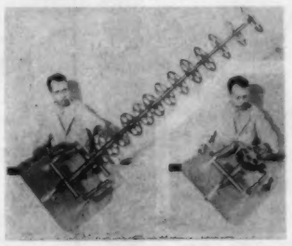
STURDY DC RELAY



New VR series miniature dc relay withstands 35 G vibration to 3000 cps and 150 G shock for 11 ± 1 msec. Occupies less than ⅓ cu-in, has DPDT contacts rated at 3 amp resistive, 28v dc. Operating power is 250 mw standard in a variety of coil resistances. Terminals 0.2" grid spaced.—*Electronics Div., Elgin National Watch Co., 2435 North Naomi St., Burbank, Calif.*

CIRCLE 180 ON READER-SERVICE CARD

COLLAPSIBLE ANTENNA



New Modular collapsible antennas, using standardized disc and rod elements can be built into a variety of patterns. Model 521A, shown, operates in 100 mph wind, has dual polarization to permit simultaneous transmission and reception, handles up to 1 kw power.—*Avien, Inc., 58-15 Northern Blvd., Woodside 77, N. Y.*

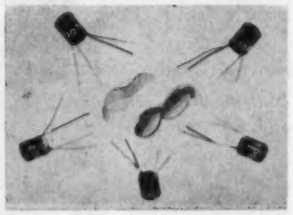
CIRCLE 181 ON READER-SERVICE CARD

PRECISION SUBMIN POT

New 341 Series rotary pot utilizes patented "V" guide and anti-backlash pins for high resolution and double wiper to eliminate intermittents caused by shock and vibration. Resistance ranges from 1K to 600K carry 2.5 watts in still air at 40°C in ½" dia by 1" long.—*Daystrom, Inc., Potentiometer Div., Archbald, Pa.*

CIRCLE 182 ON READER-SERVICE CARD

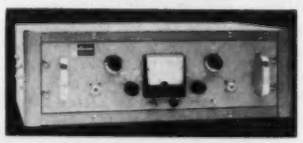
MICRO TRANSFORMERS



New micro-miniature transformers meeting MIL-T-27A, including pulse transformers, differential inputs, parallel circuit isolation and other instrumentation applications are available in standard and custom types.—*James Electronics, Inc., 4050 No. Rockwell St., Chicago 18, Ill.*

CIRCLE 183 ON READER-SERVICE CARD

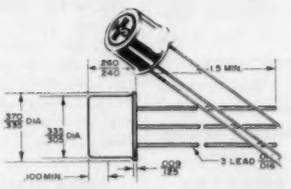
TWT AMPLIFIER



New Series 500 traveling wave tube amplifier with 1000-cycle internal modulation facilitates detection of weak cw signals with conventional lab equipment. Power output of 2 watts over 7-11 Gc range, gain is 30 db, input/output impedances are 50 ohms.—*Microwave Semiconductor & Inst. Inc., 116-06 Myrtle Ave., Richmond Hill 18, N. Y.*

CIRCLE 184 ON READER-SERVICE CARD

MINI POWER TRANSISTORS



New Model FLH portable thermoration resistance 20 times lower than other TO-5 silicon transistor switches power up to 120 watts without using heat sink. Comparable available transistors require 15 cu-in with sink; only .028 cu-in needed by 2N2033, 2N2034 and 2N2035 with I. of 0.5, 1, and 1.5 amp respectively.—*Silicon Transistor Corp., Carle Place, N. Y.*

CIRCLE 188 ON READER-SERVICE CARD

S-S ROTARY SWITCH

New solid state rotary switch uses slotted disc passing light beam to photo-sensitive diodes to provide virtually any switching sequence with angular accuracy of 0.25°. Withstands severe environments up to 100°C controlling currents of 150 ma at 28 v dc.—*White Avionics, Terminal Drive, Plainview, N. Y.*

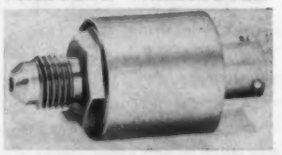
CIRCLE 185 ON READER-SERVICE CARD

GLASS SILICON DIODES

New DW series all-purpose glass silicon computer-rectifier diodes combine 400ma forward conductance at 1v, 30 nsec recovery and .025 μa reverse leakage current. PIV's from 40 v to 275 v available.—*Delta Semiconductors, Inc., 835 Production Place, Newport Beach, Calif.*

CIRCLE 186 ON READER-SERVICE CARD

PRESSURE TRANSDUCER



Miniature low-pressure potentiometer transducer, Model L-113, available in the 0-10 to 0-350 psia ranges, transmits movement of aneroid capsule through metallic belt to precision pot. Pressure media are confined within aneroid capsule, which can be made of special alloys to withstand different corrosive media.—*Servonic Instruments, Inc., 1644 Whittier Ave., Costa Mesa, Calif.*

CIRCLE 187 ON READER-SERVICE CARD

THERMAL SWITCH

New "Flatstat" miniature thermal switch withstands all environmental conditions in modern aircraft use including shock at 50 G (missile take-off), vibration at 20 G (high speeds), overshoot to 650°F or undershoot to −80°F.—*Control Products, Inc., 280 Ridgedale Ave., East Hanover, N. J.*

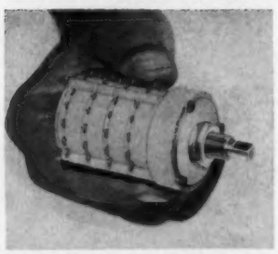
CIRCLE 189 ON READER-SERVICE CARD

A/C CIRCUIT BREAKER

New Klixon® 6752-12 circuit breaker meeting requirements for higher performance bombers provides 6000 amp rupture capacity at 120 v 400 cps—6000 amp at 30 v dc; 10 G vibration resistance, ambient temperature compensation (−65° to 250°F) and 20,000 cycle minimum life.—*Metals & Controls Inc., a Division of Texas Instruments Inc., 34 Forest St., Attleboro, Mass.*

CIRCLE 190 ON READER-SERVICE CARD

MINI ROTARY SWITCH



New miniature rotary selector switch, Series 3-1900, is designed for tap, transfer and sequence functions in airborne and ground electrical systems. Meets or exceeds all provisions of MIL-S-6807A, is rated at 5amp 115v ac and 3 amp 28v dc resistive. Supplied in 2 to 16 contacts/deck, and from 1 to 12 decks.—*Janco Corporation, 3111 Winona Ave., Burbank, Calif.*

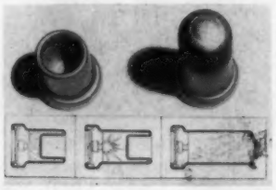
CIRCLE 191 ON READER-SERVICE CARD

CRYSTAL CASE TIMERS

New microminiature, no-moving-parts precision timers for rocket and satellite applications provide .050 to 60.0-second intervals. Both fixed and adjustable types are available, with adjustments made by a quick change of external resistance. Hermetically sealed, silicon transistor timing unit meets applicable MIL-specs, weighs only 0.8 oz.—*Tempo Instrument, Incorporated, Hicksville, L. I., N. Y.*

CIRCLE 192 ON READER-SERVICE CARD

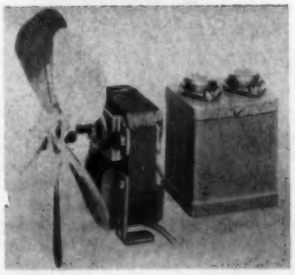
ONE-SHOT ACTUATOR



New Telecartridge energy source operating from internal propellant or from remote source of high pressure gas delivers reliable thrust to separate hatch covers, separate missile stages, dispense reagents, release airborne stores without flame, flash or smoke. 4-page bulletin describes.—*Aircraft Armaments, Inc., Cockeysville, Md.*

CIRCLE 193 ON READER-SERVICE CARD

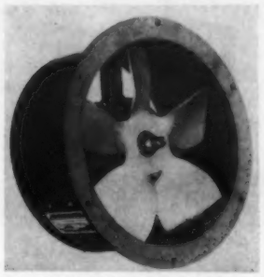
FAN/DRIVER UNIT



New Model 8-1003 ac fan with dc-powered driver unit for instruments to be operated over a wide range of power frequencies (50-1600 cps) are separately mounted on instrument chassis. Air delivery over 100 cfm, operates in ambients from −20° to 40°C with 85% efficiency, on 24 watts.—*Palo Alto Engineering Co., Palo Alto, Calif.*

CIRCLE 194 ON READER-SERVICE CARD

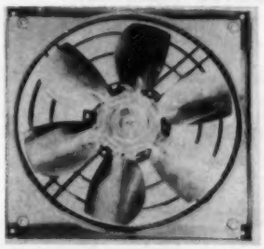
TUBE-AXIAL BLOWER



New STA-900-11430 blower with 1500 cfm air delivery at 2″ H_2O operates from 208v, 400 cps 3-phase motor, meets MIL-E-4970A, MIL-E-5272C and MIL-M-7969B.—*Specialty Blowers, The Torrington Mfg., Co., Torrington, Conn.*

CIRCLE 195 ON READER-SERVICE CARD

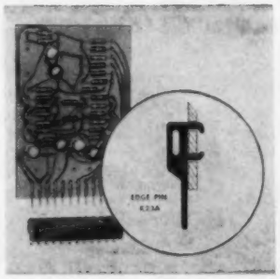
QUIET HIGH VOLUME FAN



New Model 1PB95W propeller fans deliver 550 cfm at low decibel rating. Powered by 115 v 60 cps shaded pole motor designed for continuous duty, the fans are panel-mounted for use in electronic racks, military vans or field vehicles.—*McLean Engineering Laboratories, Princeton, N. J.*

CIRCLE 196 ON READER-SERVICE CARD

CIRCUIT BOARD CONNECTORS

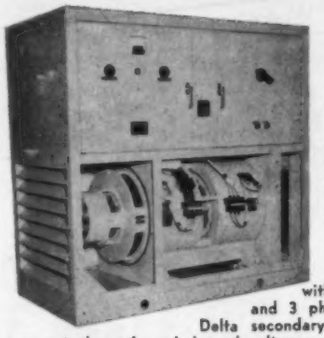


New Edge-Bord and In-Bord Pins and Cup Receptacles provide individual plug pins and receptacles which allow user to mount only the contacts actually required, providing low-cost plug-in circuit boards. Components can be used with printed circuits or manually wired boards.—*Vector Electronic Co., 1100 Flower St., Glendale 1, Calif.*

CIRCLE 197 ON READER-SERVICE CARD

Do You Have A...

WILD PHASE?



Today's manufacturer of computers, missile guidance systems, electronic device drives, etc. requires balanced, 3 phase voltages with complete isolation from transients (surges).

Factories served with both single phase and 3 phase power from a Delta secondary transformer bank may not always have balanced voltages under varying plant load (i.e. 220-220-220).

Kato Motor Generators provide adjustable voltages between any predetermined, desired range, such as 220, 230, 240 or 120/208 for laboratory or production testing.

Kato Also Builds . . . Generators—1 KW to 1,000 KW, frequencies—15 cycles to 1,200 cycles. Salient Pole Machines from 2 poles to 40 poles, Synchronous Motors, Rotary Converters, Frequency Changers.

SEND US YOUR REQUIREMENTS FOR FIRM QUOTATION!

KATO *Engineering Company* 1467 FIRST AVE., MANKATO, MINN.

Builders of Fine Rotating Electrical Machinery Since 1928!

CIRCLE 58 ON READER-SERVICE CARD

FINE WIRE

for

- Semiconductors
- Resistors
- Potentiometers
- Thermocouples
- Electronic Tubes
- Other Electronic Applications

in precious, base, exotic and special metals — bare or insulated

Custom Melting, Complete Redrawing, Strand and Vacuum Annealing Services for fine wire processing to customers' specifications.

WRITE for valuable brochure containing fine wire compositions, pertinent properties and applications.

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REACTIVE METALS, inc.
115 Hoyt Avenue — Mamaroneck, N. Y. — OWens 8-2300

CIRCLE 59 ON READER-SERVICE CARD

What dimension? Where? How fast? How many?
These quantities and many others may be accurately and instantaneously (20 μs) determined by use of the Bently distance detector.
The Bently distance detector is a precision electro-mechanical transducer. It generates a directly following (D.C.) voltage as a function of distance between its sensor head and any electrically conducting surface. Available sensitivities allow measurements from micro inches thru tenths of an inch.
D-152 precision distance detector (variable sensitivity) . . . $147.00
Sensor heads for detection . . . from $ 10.00
BENTLY SCIENTIFIC COMPANY
2811 7th St. Berkeley 10, California
Box 157, 1 Airport Road Minden, Nevada

CIRCLE 60 ON READER-SERVICE CARD

PULSE and RF

AMPLIFIERS

WITH

NANOSECOND RISETIMES

Representing a significant contribution to broad-band high-gain amplifier design, the RHG Electronics Laboratory series of pulse and rf amplifiers provide risetimes from <2 to <10 nanoseconds, negligible ringing or overshoot, and self-contained power supplies. Systems are available with characteristics other than those shown below. Higher pulse voltages, impedance levels, special configurations can be custom engineered to your specifications.

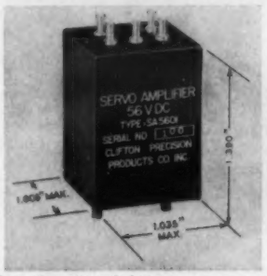
Model No.	Max. Pulse Width, 10% Droop μ Sec.	Rise-time (Nano-secs)	Peak Output Voltage (Volts)	RF Bandpass	Gain db
G50	100	<10	2.5	100 cps- 50 mcs	60
G50C	10	<10	2.5	1000 cps- 50 mcs	100
G70	100	<7	2.5	100 cps- 70 mcs	50
G70C	10	<7	2.5	1000 cps- 70 mcs	90
G100	100	<5	1.5	100 cps-100 mcs	30
G100C	10	<5	1.5	1000 cps-100 mcs	70
GT150	10	<3	0.25	1000 cps-150 mcs	40
G300	10	<2	5.0	1000 cps-300 mcs	20

Input and output impedances: Model G300—150Ω; all other models—90Ω.

RHG ELECTRONICS LABORATORY, INC.
94 Milbar Blvd., Farmingdale, N. Y.

CIRCLE 61 ON READER-SERVICE CARD

SERVO AMPLIFIER



New 5-watt miniature servo amplifier is designed to drive any size 8, 10 or 11 servo motor with a 26v control phase rating. Provides voltage gain of 54 ± 1 db from —55° to 125°C with all signal levels below saturation, and supply voltage of 56 ± 3 volts.—*Clifton Precision Products Co., Inc.*, 5050 *State Road, Drexel Hill, Penna.*

CIRCLE 198 ON READER-SERVICE CARD

SERVO ANALYZER

New Controls Analyzer Model 440, develops sinusoidal and sinusoidally modulated carrier test signal adjustable from 0.03 to 300 cps. Carrier frequencies to 5000 cps are accommodated in standard model. Can test servomechanisms or control systems without oscilloscope, or furnishes square waves for observing transient responses on oscilloscope.—*Superior Mfg. & Inst. Corp.*, 36-07 20*th Ave., Long Island City* 5, *N. Y.*

CIRCLE 199 ON READER-SERVICE CARD

SMALL AC GEARMOTORS

New line of fractional hp ac gear motors are available in hysteresis synchronous type for constant speed despite line voltage variations, or low-slip induction type for high starting torque and best full-load efficiency. Supply torques up to 300 oz-in at 1 rpm in induction type.—*Ashland Electric Products, Inc.*, 32-02 *Queens Blvd., Long Island City* 1, *N. Y.*

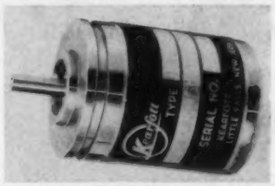
CIRCLE 200 ON READER-SERVICE CARD

BRUSHLESS SYNCHRO

New HAROSYN synchro eliminates all brushes and slipring contacts used in conventional synchros to bring power to rotor. Rotary injection transformer transfers power to rotor electromagnetically without mechanical contacts to eliminate wear, noise, sparking and to limit friction to bearing friction only. Mil-S-20708, details in Catalog 103.— *Harowe Servo Controls, Inc., Mount Road, Lenni Mills, Penna.*

CIRCLE 201 ON READER-SERVICE CARD

MOTOR-DAMPING GENERATOR



New type P820-001 size 10 short length motor-damping generator produces an output voltage linear with speed. It is ideally suited for damping applications and for short-length instrument servos. Generator output at 0 rpm is .035 v rms with 10v excitation at 400 cps. Stall torque is 0.3 oz-in, no-load speed 6500 rpm.—*Kearfott Div., General Precision, Inc.*, 1150 *McBride Ave., Little Falls, N J.*

CIRCLE 202 ON READER-SERVICE CARD

SELF-TESTING RATE GYRO

New JRS gyro employs spin motor rotating detector (SMRD) with a gimbal torquer which twists the gimbal in the same manner as precession from an actual rate about the input axis. The pick-off then generates an output signal which is used with SMRD signal in manual or automatic "go/no-go" sequences to assure the user that the gyro is running and functioning perfectly.—*Boston Div., Minneapolis-Honeywell*, 1400 *Soldiers Field Rd., Boston, Mass.*

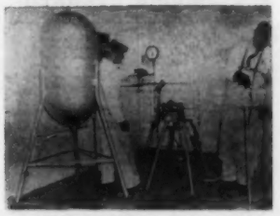
CIRCLE 203 ON READER-SERVICE CARD

SERVO CLAMPS

Market survey recently showed many prime contractors fabricate servo clamps because they are generally unavailable. Theta Clamps A-1183-1 and A-1183-2 or 3 fasten six different housing sizes to mounting panels. Samples on request.—*Theta Instrument Corp.*, 520 *Victor St., Saddle Brook, N. J.*

CIRCLE 204 ON READER-SERVICE CARD

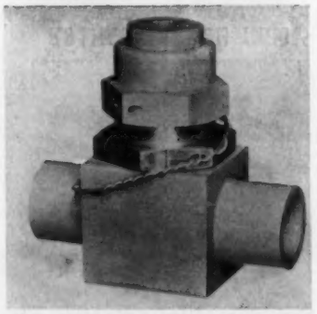
BALL VALVES



"Double-Seal" Ball Check Valve is shown being tested by Wylie Labs in Aerozine 50 test facility. Patented lip seal provides compensation for temperature, pressure and wear for continuous leakproof performance. In fully closed position, valve stem can be entirely removed from the valve with no leakage occurring through the stem port. Full details on request. —*Jamesbury Corp., New St., Worcester, Mass.*

CIRCLE 205 ON READER-SERVICE CARD

TRANSDUCER PROTECTOR



New Series 1200 Pressure Blanking Valve allows a pressure sensor, such as gauge or transducer, to function during normal low pressure operation but blanks it off if the system is subjected to pressures higher than instrument can stand. Closing pressures from 8 to 300 psi are available.—*James Pond & Clark, Inc.*, 2181 *E. Foothill Blvd., Pasadena, Calif.*

CIRCLE 206 ON READER-SERVICE CARD

MSD's January-February 1962 issue will highlight "solid-state components" including thin films, semiconductors, diodes, zeners, rectifiers, microcircuits and related devices, and related devices, and their applications in system design. Advertisers have 'til January 10 to forward copy and plates for this important issue.

MAGNETIC MODULATOR

New miniaturized, lightweight magnetic modulator for servo applications converts low-level bipolar input current to proportional phase-reversing 400 cps sinusoidal output. Input control current range is ± 250 μamp with 0-3.5 v ac 400 cps output; two isolated input windings permit additive or subtractive inputs or error-sensing output.—*Transmagnetics Inc., 40-66 Lawrence St., Flushing 54, N. Y.*

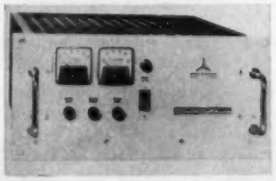
CIRCLE 207 ON READER-SERVICE CARD

PORTABLE RADAR TEST SET

New Model 121 Portable Radar Test Set provides rapid checkout of weather, navigation and anti-collision airborne radars, also radio altimeters, without physical connection to the radar systems. Checkouts previously requiring 3 to 5 hours can be accomplished in approximately 30 minutes.—*Republic Electronic Industries Corp., 111 Gazza Blvd., Farmingdale, L. I., N. Y.*

CIRCLE 208 ON READER-SERVICE CARD

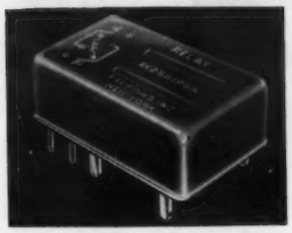
HI-CURRENT DC SUPPLY



New Century Series, covering eight units ranging from 0-15v dc at 80 amperes to 0-160 v dc at 16 amperes, features line and load regulation of better than 0.03% and ripple less than 1 mv rms. Adjustable current-limiting short circuit protection and constant current operating mode with front panel controls selecting the operating current and the desired maximum open circuit voltage are features.—*Trygon Electronics, Inc., 111 Pleasant Ave., Roosevelt, N. Y.*

CIRCLE 209 ON READER-SERVICE CARD

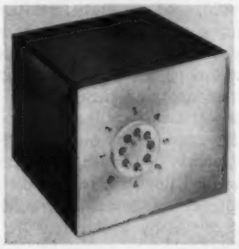
PILLBOX MINI RELAY



New AV Series 40-milliwatt relay with flat-mounting header for printed circuit assemblies uses same motor as "Miniwatt" (JV Series) sensitive relay, operates reliably under 15G vibration and 50G shock. Hermetically sealed, the AV Series is supplied with SPDT and DPDT circuits, with contacts for 2 amp dry loads.—*Filtors, Inc., 30 Sagamore Hill Drive, Port Washington, N. Y.*

CIRCLE 210 ON READER-SERVICE CARD

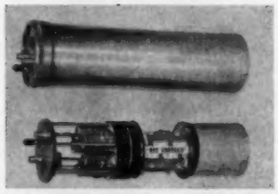
MAGNETIC AMPLIFIER



Miniature Model MA110 high-gain, self-saturating magnetic amplifier delivers up to 75 watts with only 2ma signal current. Input of 115v rms, 400 cps; output is .75 amp rms 110v with response time of 8 msec. Sealed and potted unit weighs only 2⅛ lbs. —*Dynex Industries, Inc., 170 Eileen Way, Syosset, N. Y.*

CIRCLE 211 ON READER-SERVICE CARD

MISSILE TRACKING TRANSPONDER



New transponder receiving on 37 mc and transmitting on 74 mc with power output between 1 and 1.35 watts enable ground station to determine speed and position of test vehicle. Operates for 15 minutes on rechargeable Ag-Cd battery over temperature range from −20° to 72°C.—*Frequency Standards, P. O. Box 504, Asbury Park, N. J.*

CIRCLE 212 ON READER-SERVICE CARD

HIGH-ACCURACY PRECISE ANGLE INDICATOR

NEW KEARFOTT UNIT ACCURATE TO ±6 MINUTES

The new CO 2721011 Precise Angle Indicator features an accuracy of ±6 minutes. Latest addition to the Kearfott line of standard test equipment, the unit is designed to meet a wide range of applications. Typical Applications • Indication of gyro angle of pitch, roll, or yaw and relaying of signal to any preselected impedance or voltage level. • Indication of shaft position of remote synchro or resolver, and transmission of this information to any impedance or voltage level. • Display of difference between two shafts when driven by transmitter and differential synchros.

In addition to high accuracy the instrument combines a number of other prominent advantages: it requires only a single power source; it has good sensitivity; it is designed for modular application; and it offers direct automatic readout. The unit is of extremely compact construction and is built for maximal ease of maintenance.

The low-cost CO 2721011 Precise Angle Indicator is available with a single sensor, auxiliary dual-input sensor, or an auxiliary retransmitter. For additional information on this new test instrument, write for the brochure which describes its operation and capabilities in detail.

SPECIFICATIONS

Repeatability	±1.2 min	**Slewing Speed**	7 sec/180°
Readability	0.5 min	**Power (single source)**	115 v, 1φ, 400 cps
Input Power	30 va	**Size**	1¾ x 9½ x 9⅛ in.
Sensitivity	1.0 min	**Weight**	4 lbs.

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GENERAL PRECISION, INC.

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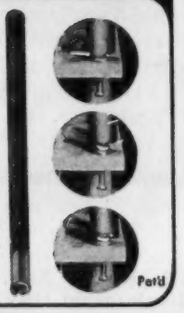

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PROTECTIVE NETWORK

New Solitron solid-state protective network for operating into inductive loads protects against inductive spikes to 1,500 v peak. Rated at 125 v dc 2 amps dc over the −65° to 150°C temperature range.—*Solitron Devices, Inc., 500 Livingston St., Norwood, N. J.*

CIRCLE 213 ON READER-SERVICE CARD

VARIABLE DELAY LINE

New continuously variable delay line delivers from 0 to 0.7 μsec with resolution of 0.001 μsec in prototypes when exact delay specification is unknown or where final circuit tuning is required. Rise time 0.09 μsec impedance 500 ohms, attenuation 1 db max.—*Valor Instruments, Inc., 13214 Crenshaw Blvd., Gardena, Calif.*

CIRCLE 214 ON READER-SERVICE CARD

IF CERAMIC FILTERS

New ceramic filters replacing IF transformers in transistor and tube circuits feature smaller size, permanent tuning, simplicity of design, high temperature stability, ruggedness and single spurious response harmonically unrelated to the center frequency.—*U. S. Sonics Corp., 63 Rogers St., Cambridge 42, Mass.*

CIRCLE 215 ON READER-SERVICE CARD

VARIABLE DELAY LINE

New magnetostrictive delay line adjusted by a single multiturn screw permits an infinite variations in delay time from 2μsec to 20 μsec. Pulse reprate is 500 kc max while input noise width is 1.0 μsec. Insertion is approx 45 db and input and output impedances are 400 ohms.—*Deltime Inc., 608 Fayette Ave., Mamaroneck, N. Y.*

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Wiley BOOKS

STATISTICAL ANALYSIS AND OPTIMIZATION OF SYSTEMS

By E. L. PETERSON, *Technical Military Planning Operation, General Electric Co.* Gives integrated coverage of much of the new work on control systems. Major part deals with analysis, synthesis, and optimization of systems where statistical uncertainty is involved in the process dynamics. Analytical problems are developed, computational procedures described, and numerical results generated for specific examples. Concepts are illustrated by examples worked out by hand in enough detail to show either complete results or the means by which they are obtained.

INCLUDES: Linear systems theory. Statistics of random variables. Response to distributed inputs. Systems analysis and design. Optimum systems. Applications in optimal synthesis. Optimization with multiple inputs and outputs. Optimizing inputs for specified linear systems. Multi-dimensional, nonlinear, boundary-valued variational problems.

1961. 190 pages. $9.75

The Mechanics of Inertial Position and Heading Indication

By WINSTON MARKEY and JOHN HOVORKA, both of M.I.T. A concise, rigorous treatment of the synthesis of inertial navigation systems, which can be applied immediately to practical work in the field. 1961. 92 pages. $3.95

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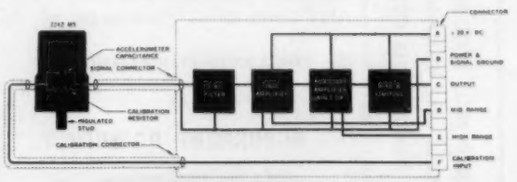
Signal Piezoelectric

The signal requirements of the sub-carrier oscillator in a telemetry system are several and varied. They must be reliably met if good data are to be obtained. For the first time a signal conditioner, the Endevco Model 2630 Series, is available in a single package (1" x 2.5" x 2.6") to do this job.

The new integrated system (Fig. 1) provides the following features:

Filtering at the amplifier input. This provision, made possible by the Endevco "charge" amplifier (because transducer charge is independent of cable capacitance), provides a choice of low-pass filters to reduce the frequency content of the vibration data to avoid interference with other channels in the telemetry system (Fig. 2). This filtering also avoids overloading of the amplifier from high frequency signals outside the range of interest. Such overloading causes loss or distortion of useable signal. Pre-amplifier filtering cannot be used with the conventional high input impedance voltage amplifier.

Output signal limiting and biasing. Excessive signal voltage entering the sub-carrier oscillator may overload the system. Also biasing of the input signal is normally



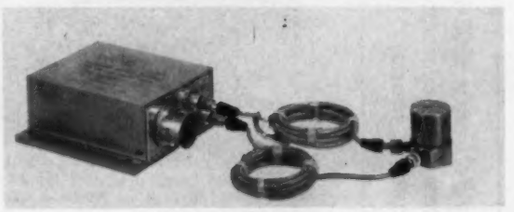


FIG. 1. SIGNAL Conditioner and Accelerometer with block diagram of typical 2630 Series System.

required by the subcarrier oscillator. The Endevco 2630 Series provides limiting in the range of 2.0 v to 6.0 v peak-to-peak, and bias from 0-4.3 volts.

Power regulation. Power variations from nominal 26 v up to 40 v result in output signal transients not to exceed 200 mv peak-to-peak.

Conditioning with Transducers

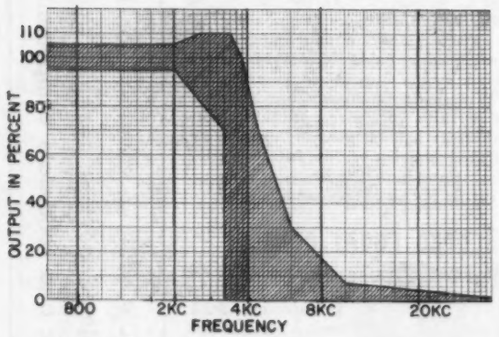


FIG. 2. FREQUENCY RESPONSE Limits for 2633M5 Amplifier.

Amplification as required. The "charge" amplifier is fully transistorized and is not affected by transducer cable lengths up to several hundred feet. Changes of transducer cable length will not affect system calibration. Also, the low input impedance of the amplifier minimizes humidity effects which may degrade the performance of conventional high input impedance voltage amplifiers normally used with crystal vibration transducers. Several stages of variable gain are available to accommodate the wide range of vibration levels encountered in vehicle testing.

In-Place Calibration. Calibration of the system after attachment to the test vehicle is possible with the 2630 Series by several methods: Signal insertion at the transducer (via calibration input jack) is possible with Endevco accelerometer Models 2242M5 and 2213M7 which incorporate a special resistor in the base. Calibration insertion resistors within the amplifier can also be supplied.

Endevco accelerometers can be supplied with a second internal crystal driven by a signal generator to mechanically excite the measuring crystal. This procedure can be incorporated in the 2630 Series.

Use with Crystal Microphone. The 2630 Series systems can be used with piezoelectric microphones or any other piezoelectric transducer, such as force gages or pressure pickups . . . (*From* 2630 *Series data folder, including typical performance specification for* 2633-*M5A Amplifier, Endevco Corporation,* 161 *East California Boulevard, Pasadena, Calif.*)

FOR THIS LITERATURE CIRCLE 217 ON READER-SERVICE CARD

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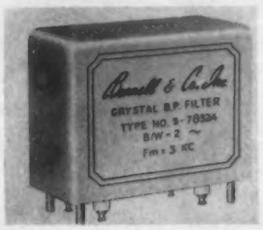
CRYSTAL FILTER



New 3 kc miniature crystal filter for use in missile, communication and control applications features insertion loss of 3.5 db, attenuation of 3 db in 2 cps bandwidth, T. C. of 0.021 cps/°C, also input and output impedances of 500 kohms.—*Burnell & Co., 10 Pelham Pkwy, Pelham, N. Y.*

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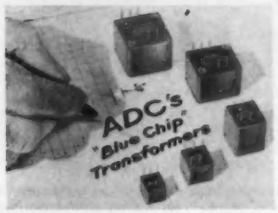
PRINTED CIRCUIT TRANSFORMERS



New encapsulated transformers for printed circuit applications range from 0.08 to 1.2 cubic inches. 64 new units offer choice of power levels for voice and extended frequency operation, meet MIL-T-27A, Grade 5, Class S requirements.—*ADC Incorporated,* 2833 13*th Ave., So., Minneapolis* 2, *Minn.*

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TUNNEL DIODE AMPLIFIERS

New OTA-I series octave bandwidth low-noise tunnel diode amplifiers with isolation gives low noise figures over very broad band of frequencies. Self-contained broadband vacuum tube stage isolates unit to prevent L. O. leakage or load VSWR. Max power input 200 mw cw or 20 watts peak.—*Micro State Electronics Corporation,* 152 *Floral Ave., Murray Hill, N. J.*

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HOT SPOT TRIM POTS

New high temperature, trimmer potentiometers with stepless resolution are produced by fusion of an oxide on glass substrate. T/C is only 50 ppm/°C, and unit has high heat dissipation capabilities, operating in ambients from −65° to 150°C.—*Intellux, Inc., 30 South Salsipuedes St., Santa Barbara, Calif.*

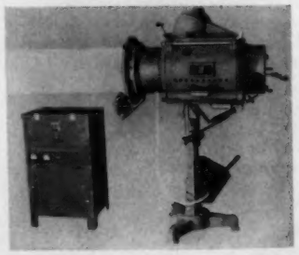
CIRCLE 221 ON READER-SERVICE CARD

MICROWAVE RECEIVER/ ANALYZER

New transistorized Model TR receiver/analyzer for quantitative analysis of microwave signals, FM and AM, covers frequencies from 950 to 11,260 mc, analyzes pulse signals, has outputs for audio, video and recorder.—*Polarad Electronics Corp., 43-20 34th St., Long Island City 1, N. Y.*

CIRCLE 222 ON READER-SERVICE CARD

SOLAR SIMULATOR



New Solar Radiation Simulator produces from carbon arc a beam of collimated radiation with same spectrum, intensity and divergence as sunlight in outer atmosphere, for testing and development of space vehicles and components.—*GENARCO Inc., 97-04 Sutphin Blvd., Jamaica 35, N. Y.*

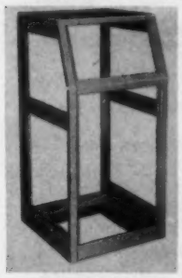
CIRCLE 223 ON READER-SERVICE CARD

PHASE-STABLE CABLE

New techniques produce coaxial cable with a phase shift of only 20 ppm°C within the range of 10° to 32°C, only 1/10th normal phase shift of coaxial cable in this range. The phase stable cable is manufactured with a sweep impedance tolerance of ± 2 ohms at frequency bands specified by the customer; standard UG connectors can be used.—*Times Wire & Cable, division of The International Silver Company, Wallingford, Conn.*

CIRCLE 224 ON READER-SERVICE CARD

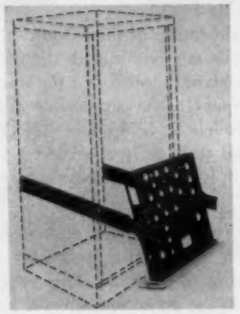
SLOPED FRONT CONSOLE



New Sloped Front Console frame of #14 gauge steel is designed for multiple installations and accommodates 19" and 24" panels. Front slopes 19° from vertical and all panel mounting angles are made of #12 gauge steel tapped 10/32 on E. I. A. spacings with front and rear vertical angles adjustable to any position.—*Premier Metal Products Co., 337 Manida St., New York 59, N. Y.*

CIRCLE 225 ON READER-SERVICE CARD

SLIDE FITS ALL CHASSIS



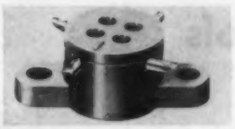
New Universal Chassis Slide, in eight sizes, is complete for detent, tilt or non-tilt assembly; for front and back mounting, front mounting only or side mounting only. Features of weight saving, dry permanent lubrication, push-button release and safety features are described in technical brochure.—*Metal-Craft, Inc., 34 Burgess Place, Wayne, N. J.*

CIRCLE 226 ON READER-SERVICE CARD

READERS AND ADVERTISERS have much to look forward to in MSD's editorial coverage for 1962. Scheduled for special "design application" treatment are: Synchros, servos and related devices; resistors and reactive components; power supplies; microwave components; commutating devices; and solid-state components.

MSD's January-February 1962 issue will highlight "solid-state components" including thin films, semiconductors, diodes, zeners, rectifiers, microcircuits and related devices, and related devices, and their applications in system design. Advertisers have 'til January 10 to forward copy and plates for this important issue.

TRANSISTOR SOCKET



New surface mounted Model XS-T4 socket for JETEC 30 transistors features closed entry socket contacts of silver-plated beryllium-copper. Accessible contact tabs are clearly identified. Body is low-loss mica-filled phenolic casting per MIL-M-14, type MFE.—*Pomona Electronics Co., Inc., 1500 E. Ninth St., Pomona, Calif.*

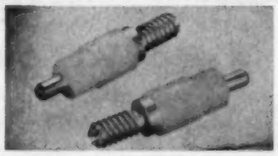
CIRCLE 227 ON READER-SERVICE CARD

TRANSISTOR RADIATOR/ RETAINER

New double-ended combination radiators and retainers for transistor mounting are available to fit most TO-type transistors. Positive retention and up to 27% reduction in heat extends transistor life and prevents thermal runaway.—*The Birtcher Corportation/Industrial Div., 745 S. Monterey Pass, Ponterey Park, Calif.*

CIRCLE 228 ON READER-SERVICE CARD

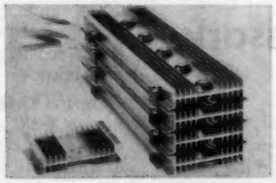
HIGH-TORQUE TERMINAL



New "Press-Fit" Teflon terminal Type FT-500 TI threaded feedthru has screwdriver slot milled across the threaded stud for holding the mounted terminal while applying high torque to terminal nut.—*Sealectro Corporation, 610 Fayette Ave., Mamaroneck, N. Y.*

CIRCLE 229 ON READER-SERVICE CARD

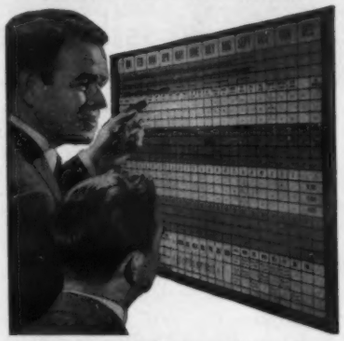
HEAT DISSIPATORS



New transistor heat dissipators with assortment of mounting-hole patterns to fit all common power transistors has cooling fin configuration compatible with most available blowers. Stack-mounts on insulators.—*Invar Electronics Corp., 1723 Cloverfield, Santa Monica, Calif.*

CIRCLE 230 ON READER-SERVICE CARD

You Get Things Done With Boardmaster VisualControl



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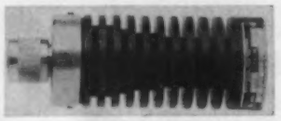
COAX TERMINATIONS



New precision high power coaxial terminations for laboratory and QC test dissipate 20 watts CW with 6KW peak pulse power. Model 624 covers 400-500 mc, Model 569 covers 1200-1400 mc range. Max VSWR is 1.05, both use Weinschel stainless steel Type "N" connectors.—*Weinschel Engineering Co., Kensington, Md.*

CIRCLE 231 ON READER-SERVICE CARD

NARROW BAND TERMINATIONS

New 2300 Series ultra-compact narrow band terminations for use in S, C, X, and K-type waveguides, cover any 6% bandwidth with a maximum VSWR of 1.5 and 30 db or more attenuation.—*Custom Components, Inc., Caldwell, N. J.*

CIRCLE 232 ON READER-SERVICE CARD

Continued on page 66

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WHY HIGH-PERFORMANCE RECTIFIERS EMPLOY CERAMASEAL HIGH-ALUMINA HOUSINGS

Typical Ceramaseal high-alumina housing, full size

Higher performance ratings in recently introduced rectifier designs have placed higher demands on rectifier **housings.** Ceramaseal high-alumina housings provide the answer — with these advantages over glass:

PERMIT HIGHER TEMPERATURES
Ceramaseal housings remain high-vacuum tight during continuous operation at 350 C in air.

SURVIVE TOUGHER OPERATION
Housings by Ceramaseal withstand greater mechanical and thermal stresses than glass without cracking or failure of high-vacuum-tight seal.

PROVIDE LONGER CREEPAGE PATHS
In compact housing designs, high-alumina ceramic provides longer creepage paths than glass.
You can apply Ceramaseal housings with conventional welding methods. For information on your application, write:

Hermetic Ceramic Terminals, Magnetron Wells, Sapphire-to-Metal Seals

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NEW MINIATURIZED COMMUTATING SWITCH

- IDL "STANDARD" Performance and Flexibility in ⅓rd the Volume
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- **Clamped Speed Regulator** holds Pole Speed to 2%
- **Phase-Lock Concept** controls speed of 4 or more independent switches

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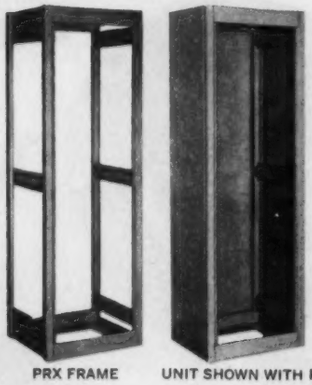
PREMIER introduces

NEW MODULAR SQUARE CORNERED RACKS DESIGNED FOR MULTIPLE INSTALLATIONS



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UNIT SHOWN WITH FLUSH SIDE PANELS

- 18" and 24" DEEP for 19", 24" and 30" PANELS
- Available in 22 different sizes
- Tops of front and rear are square
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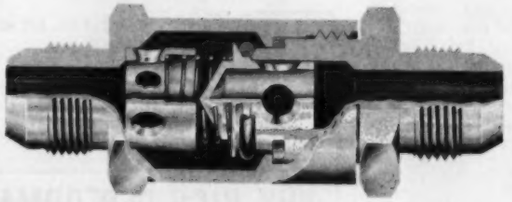
CIRCLE 72 ON READER-SERVICE CARD

Check Valve Controls Missile Fuels

Unequalled reliability is achieved by Circle Seal 200 Series check valves in handling hazardous missile fuels including hydrazene, LOX and nitrous oxide. A wide range of body materials and "O"-rings are available to meet normal and most abnormal temperatures and pressures in the 0 to 3000 psi range.

Full flow passages offer minimum restriction to flow, even at low pressure differentials. Opening pressures are as low as ½ psi and the poppet closes at zero flow before the return flow starts. Operation is shown in the illustration for open, closing and closed positions.

When open the spring is completely removed from the flow path. As differential pressure approaches zero the floating "O" ring automatically establishes line contact with conical metal surfaces of poppet and seat to cushion the closing action and insure perfect sealing. In closed position, and when carrying full back-pressure load the metal-to-metal seal supports the "O" ring.



The pulsating action of shock waves and hammer is absorbed by minor expansion and contraction of the "O" ring. "Teflon", neoprene and "Kel-F" are only a few of the "O" ring materials available for specialized application . . . (*From 32-page catalog, "Circle Seal Valves", James, Pond & Clark, Inc., 2181 East Foothill Blvd., Pasadena, Calif.*)

FOR THIS LITERATURE CIRCLE 233 ON READER-SERVICE CARD

Reliability Test Glossary

Term	*Definition*
MTTF	— Mean Time to Failure is total number of hours divided by the number of failures (shorted or opened) within the useful life area.
Unit Hours	— Number of parts on test multiplied by the time in hours on test.
Failure Rate	— The reciprocal of MTTF. It is expressed in % failures per unit hours. Symbol is λ.

Troubled with LEAKS you didn't find?

Don't let it bruise your ego.

Whether your trouble is leak testing large tanks or production line testing of the tiniest sealed components, CEC bails you out with two new instruments boasting spectacular performance. One is the 24-120 Leak Detector, a helium/mass spectrometer instrument so versatile it locates and measures leaks in parts of all sizes with instrument sensitivity of 5 x 10^{-11} atm cc/sec helium. Or consider the 24-510 Radiflo Leak Detector for 100% (and lowest unit cost) testing of sealed electronic devices. It has a sensitivity of 1 x 10^{-11} atm cc/sec air.

For full information, call your nearest CEC sales and service office or write for Bulletin CEC 24120-X14 and Bulletin CEC 24510-X9.

Analytical & Control Division

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CONSOLIDATED ELECTRODYNAMICS

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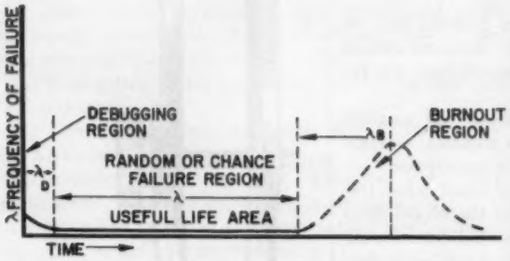
CIRCLE 73 ON READER-SERVICE CARD



Debugging — The removal of early failures by stressing the parts for a given number of hours at elevated temperatures and voltages.

Useful Life — The time after debugging and before burnout. During this time the rate of random failure is approximately constant.

Burnout — The time following useful life during which the failure rate increases above the random failure rate.

. . . (*From* 10-*page Bulletin* 516, *Reliacon Ceramic Capacitors, Erie Electronics Div., Erie Resistor Corp., 645 West 12th St., Erie, Pa.*)

FOR THIS LITERATURE CIRCLE 234 ON READER-SERVICE CARD

Electronic Nose Detects Toxic Fuels

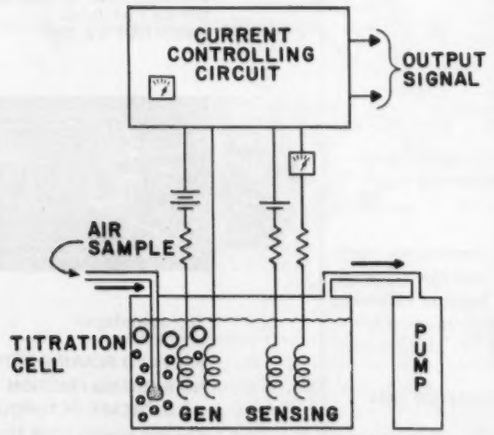


FIG. 1. FUEL OLFACTRON, Model 4070, is designed to sense and measure small concentrations of toxic unsymmetrical dimethyl hydrazine missile fuel vapor in the air.

Although most of men's senses have been rendered more acute and active over a wider range through the use of electronic transducers and amplifiers, his sense of smell—never as acute as that of many lower animals—has until now defied electronic simulation. Recently, the

Continued on page 64

NEFF INSTRUMENT CORPORATION, WITH MANY PROVEN CONTRIBUTIONS TO INSTRUMENTATION, INVITES YOUR INSPECTION AND EVALUATION OF THESE RECENTLY INTRODUCED AMPLIFIERS. THEY HAVE BEEN DESIGNED TO SATISFY TODAY'S MORE CRITICAL APPLICATIONS. NEFF CUSTOMERS KNOW THAT EACH AMPLIFIER WILL MEET ITS PUBLISHED SPECIFICATIONS. FOR *YOUR* CRITICAL AMPLIFIER APPLICATIONS — LOOK TO NEFF.

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TYPE 101B AN EXTREMELY RELIABLE SOLID STATE DIFFERENTIAL DC AMPLIFIER COMBINING HIGH GAIN, LOW NOISE, HIGH INPUT IMPEDANCE AND LOW OUTPUT IMPEDANCE WITH INTERCHANGEABLE PLUG-IN FILTERS. THIS AMPLIFIER IS IDEAL FOR NARROW BAND REQUIREMENTS WHERE NOISE OR GROUND CURRENTS CREATE PROBLEMS.

TYPE 106 A SOLID STATE BROAD BAND, SINGLE ENDED LOW GAIN DC AMPLIFIER PARTICULARLY APPLICABLE AS A GALVANOMETER DRIVER OR LINE DRIVER. THE AMPLIFIER FEATURES HIGH OUTPUT CURRENT, LOW OUTPUT IMPEDANCE, AND OPTIMUM ISOLATION. A DUAL OUTPUT IS PROVIDED — DIRECT OR THROUGH A PLUG-IN DAMPING NETWORK WHICH ACCOMMODATES THE RESISTANCE NECESSARY TO MATCH ANY GALVANOMETER.

CIRCLE 74 ON READER-SERVICE CARD

NANMAC CORPORATION

is proud to introduce the . . .

"PLASTIC THERMOCOUPLE"

The body of the Model "P" thermocouple can be fabricated from any plastic, plastic-mineral composites, non-metal, alloy, or special proprietary material. Thus surface or in-wall temperatures of a wide variety of materials can be measured accurately without disturbing the normal heat distribution pattern caused by differences in thermal properties. Examples of materials successfully used in the Model "P" include: plexiglass, asbestos phenolics, graphite, copper, molybdenum and special proprietary plastics.

MODEL-P

(Actual Size)

OVER 5000° F.!

FEATURES

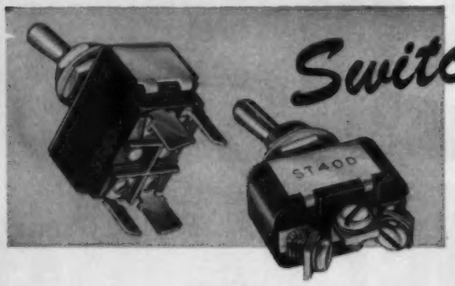
- √ Response time—less than 10 microseconds to transient temperatures.
- √ Thermal junction maintained even during erosion.
- √ Temperature range from —320° F to over 5000° F.
- √ Pressure range to over 5000 PSI.
- √ Two-dimensional thermal junction for accurate location of point of measurement.
- √ Thermocouple constructed of flat ribbon wires and mica insulation.

NANMAC CORPORATION

P.O. BOX 8 INDIAN HEAD, MARYLAND

WRITE FOR BULLETIN TB161

CIRCLE 75 ON READER-SERVICE CARD



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Designed and built for long, rugged, dependable service, Kulka Toggle Switches provide positive, precise switching for electronic and electrical circuits. Made to Joint Army and Navy Specifications JAN-S-23, MIL-S-21195, MIL-S-6745 and MIL-S-3950A. Available in SPST, SPDT, DPST and DPDT types, DC and AC up to 1600 cps.

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Now, specify the terminal type best suited to your needs. Standard screw terminal, hole-through solder type, or male tab for accepting Burndy, AMP or Kent female slip-on connectors.

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CIRCLE 76 ON READER-SERVICE CARD

Olfactron, a development of American Systems Inc., of 1625 East 126th St., Hawthorne, Calif., demonstrated an ultrasensitive ability to detect toxic vapors very similar to the human sense of smell.

Development of the principle to detect and measure other gas and liquid concentrations in chemical warfare defense, chemical process control, etc. is anticipated.

Of particular value in the detection of small concentrations of toxic missile fuel, the action of the Model 4070 Fuel Olfactron is shown in Fig. 1. In the fuel detector, the fuel vapor is reacted with bromine. The bromine is electrolytically produced at a platinum anode by passing a direct current through a solution of bromide salt. A second pair of platinum electrodes are used to sense the presence of bromine in the circuit. When a low voltage is impressed on the sensing electrodes a current, proportional to the bromine concentration present, flows.

A current-controlled relay turns the generating current off at high levels of free bromine, and on at lower levels, controlling the amount of bromine supplied to balance the fuel vapor absorbed from the sampled air.

The level of electrical current as indicated on a meter or record chart corresponds to the concentration of vapor in the sample (Fig. 2). Significant readings are obtained for concentrations as low as 0.5 ppm and a range of 250 ppm is practical.

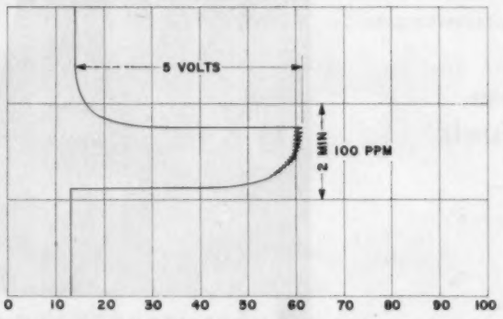


FIG. 2. RESPONSE of the Olfactron is rapid; lends itself to control and continuous monitoring applications.

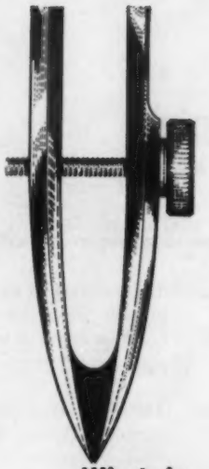
Because the Olfactron is capable of continuous operation and has a rapid response rate, leakage of toxic liquids can be detected before hazards become excessive . . . (*From 16-page Olfactron Demonstration Report, American Systems, Inc., 1625 E. 126 St., Hawthorne, Calif.*)

FOR THIS LITERATURE CIRCLE 235 ON READER-SERVICE CARD

Threaded Miniature Coaxial Couplings

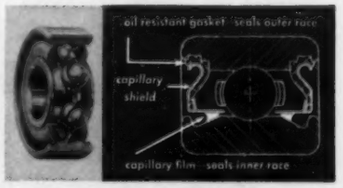
The TM® Series of RF connectors is a development by General RF Fittings, Inc., designed to meet increasing demands for miniature thread-coupled, precision-engineered connectors for the new lightweight small cables in airborne, missile and other new design applications.

TM Series connectors have many of the same features of the regular GRFF TNC Series, such as:



What do Bow Pens have to do with Miniature Bearings?

They help us illustrate the principle behind our famous RMB Filmoseal construction. The ink in a bow pen is held in place by capillary action—so is the oil that forms the seal in the Filmoseal bearing. This means sealing is accomplished with no rubbing mechanical contact between rotating and stationary members.
Here's how it looks:



The advantages are obvious:

A SEALED BEARING WITH—

NO RUBBING FRICTION

NO INCREASE IN TORQUE

You can specify RMB Filmoseal bearings to *low cost* ABEC 1, or 5 or 7 tolerances. Sizes available range from .1875" OD/.0550" Bore to .8661" OD/.3150" Bore. Immediate delivery. Write for complete data.

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CIRCLE 77 ON READER-SERVICE CARD

1. Heat treated beryllium copper female and shield contacts to prevent loss of contact pressure due to use, thus eliminating contact noise.

2. Gold plated center and shield contacts for low contact resistance.

3. Threaded couplings and safety wire holes for locking under severe vibration conditions.

4. Impedance matching with cables for low VSWR up to 8 kmc. Standard impedance is 50 ohms.

5. Improved type BNC-TNC cabling for ease in assembly. (See Assembly Instructions).

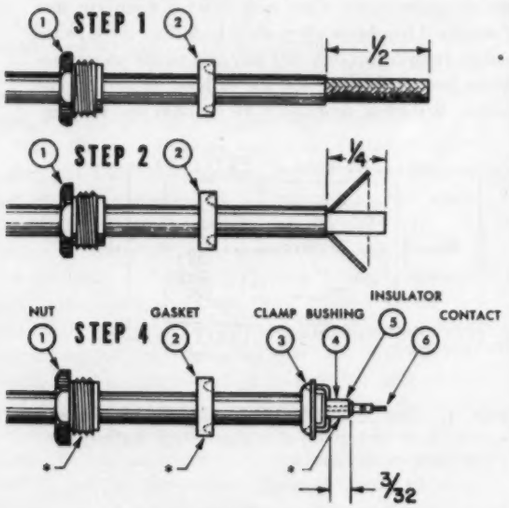
TM Series—Cable Assembly Instructions

Step 1—Place parts 1 and 2 over cable and cut off jacket to dimension shown. Be careful not to nick braid.

Step 2—Comb braid wires and fold in or out. Cut dielectric to dimension shown.

Step 3—Pull braid wires forward and taper toward center conductor. Place part 3 over braid and push back against cable jacket.

Step 4—Fold back braid wires. If necessary, trim to proper length and form over part 3 as shown. Add part 4 (brass bushing) and part 5 (insulator over dielectric. Solder contact (part 6)



to center conductor removing all excess solder. Parts 4 and 5 are not required with cables having a dielectric of .100" dia or more.

Step 5—Insert cable and parts into connector body. Make sure that part 2 is properly seated with sharp edge of part 3 entering groove in part 2. Part 1 is rotated until gasket is split and good contact between parts 1 and 3 is assured.

*Apply a light film of dielectric compound (Dow-Corning DC-4) before assembly of body.

(*From new 32-page catalog, Threaded Coaxial Connectors, General RF Fittings, Inc., P. O. Box 6892, Towson, Md.*)

FOR THIS LITERATURE CIRCLE 236 ON READER-SERVICE CARD

Precision in miniaturization. The Clarostat Series 57M ½" diameter potentiometer is designed for use as a pad or trimmer under extreme temperature, moisture, shock and vibration conditions. Series 57EM utilizes glass sealed terminals for operation up to 150°C.

Brief specifications: 57M — 1.75 watts @ 70°C; 57EM — 2.0 watts @ 70°C; Dielectric strength — 1000 volts AC; Maximum resistance standard, up to 25,000 ohms, special up to 100,000 ohms; Resistance tolerance ± 10%, on special order to ± 3%; Functional output linear; Independent linearity ±2%.

write for complete precision catalog...

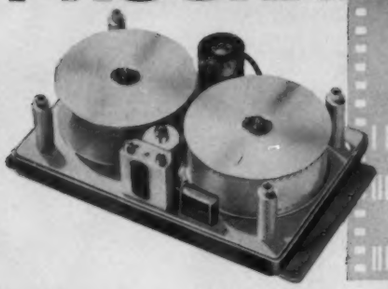
CLAROSTAT

CLAROSTAT MFG. CO., INC. DOVER, NEW HAMPSHIRE

CIRCLE 78 ON READER-SERVICE CARD

Proved, Accurate, Reliable

PROGRAMMING



- Missile Guidance
- Ground Check-out
- Jet Engine Testing
- Industrial

13 CHANNELS — 4 HOUR PROGRAM

Where precise timing, maximum flexibility, minimum size and weight are needed in a programmer that has proved itself in numerous field applications, Beattie-Coleman MLPR13 meets all requirements. Controls programs up to 4 hrs., 42 min. duration on 13 channels. Programs quickly changed by inserting new punched 35mm Mylar tape. Reliability: 99.999%. Specified by Aerojet, Bendix, Convair, Douglas, Lockheed, Martin, North American, RCA, Ryan, Sandia and others. Send for catalog on this and other models to fit your needs.

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1116 N. Olive St., Anaheim, Calif. • PR 4-4503

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..HIGH VOLTAGE TESTING

of Electronic Cables, Components, Materials and Completed Assemblies

Mobile D-C HYPOT®

Rugged . . Mobile . . for Production, Installation and Maintenance Testing

Output . . 120 kv models provide up to 5000 microamperes d-c. 75 and 45 kv models offer up to 10 ma, d-c.

115v A-C Line . . Input through three-conductor power cord with standard two prong plug and grounding clip.

Self-Contained, Fully Portable . . Single mobile housing with rubber tired wheels and push handle contains metering circuitry and high voltage supply (oil immersed above 45 kv).

Safe, Simple Operation . . Direct reading of insulation leakage current. Fully interlocked, cabinet grounded, output cable shielded . . to protect operator and equipment.

. . for Every Application

Heavy Duty HYPOTS® A-C or D-C, to 150 kv.

Bench Type HYPOTS® A-C to 35 kv, 2 kva; D-C to 45 kv, 25 ma

Mobile HYPOTS® A-C to 30 kv, 10 kva; D-C to 120 kv, 10 ma

Portable HYPOTS® A-C to 10 kv, 230 va; D-C to 5 kv, 2 ma

Write for Manual J-67

"Methods for Insulation Testing . . Engineering . . Production . . Maintenance

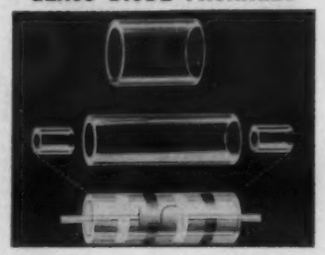
4-35.9

ASSOCIATED RESEARCH, Incorporated

3741 W. Belmont Ave., Chicago 18, Illinois

CIRCLE 80 ON READER-SERVICE CARD

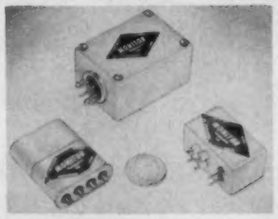
GLASS DIODE PACKAGES



Multiple glass tubes are cut to square smooth-end configurations holding a tolerance of .002" max on length, parts are ultrasonically scrubbed, rinsed in deionized water, electronically inspected in filtered atmospheres, mechanically packed to prevent contamination.—*T. H. Garner Co., 177 South Indian Hill Blvd., Claremont, Calif.*

CIRCLE 237 ON READER-SERVICE CARD

CRYSTAL/TRANSISTOR OVENS



New miniature temperature-control ovens for crystals and other temperature-sensitive components hold temperatures at ±1°C, are easily modified for customer requirements. Bulletin NP-1 describes.—*Monitor Products Co., Inc., 815 Fremont Ave., South Pasadena, Calif.*

CIRCLE 238 ON READER-SERVICE CARD

COAXIAL CRYSTAL MIXERS

New XR series single-ended coaxial mixers cover the 225mc to 6 kmc region in seven overlapping frequency ranges. Each is fixed-tuned and requires no RF adjustment. The mixers use standard ceramic cartridge type crystals and local oscillator coupling can be varied over a 13 db range. Available with N, C, BNC, TNC and microdot output connectors.—*Microlab, 570 West Mount Pleasant Ave., Livingston, N. J.*

CIRCLE 239 ON READER-SERVICE CARD

Products Continued on page 71

Brushless AC Generators

Emergency Power

BRUSHLESS generation of alternating current power has long been a goal of power generator designers. Military requirements during World War II led to the initial development of these devices with some success. However, the full promise of brushless commutation could not be realized until compact and efficient solid-state rectifiers were developed. Today a number of manufacturers offer models of brushless alternators.

The Kato Engineering Company of Mankato, Minn., has been active in the early development of brushless alternators, supplying several brushless models for special applications. They now offer a complete line of standard brushless alternators including three-phase ratings from 5 through 400 kw, and single phase machines from 5 through 150 kw in both 50 and 60 cps models. Brushless generators up to 1200 cps frequen-

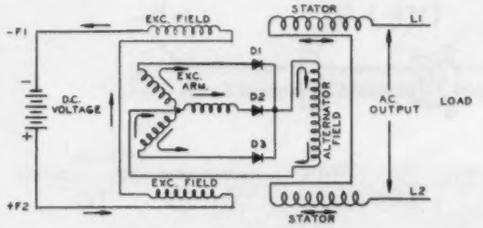
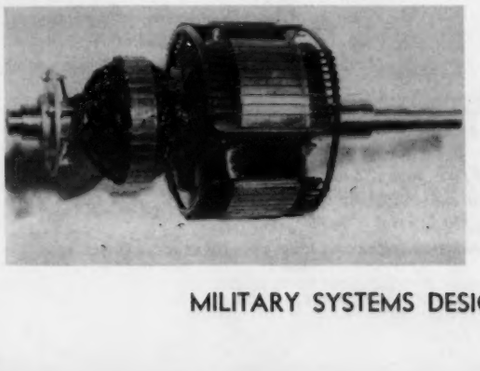


FIG. 1. SIMPLE BRUSHLESS ALTERNATOR has exciter field on stator energized from battery or other standby dc source.

FIG. 2. ROTATING COMPONENTS of Brushless Alternator include exciter armature, diode bridge rectifier (on aluminum mounting plate and heat sink) and four-pole alternator field. No electrical connections are needed between rotating components and stator.



for Military and

F. L. NELSON, Chief Engineer,

Kato Engineering Co.

cy are available, with still higher frequencies supplied from salient-pole, induction type models.

The characteristics of brushless alternators which are particularly desired for military applications include (1) sparkless commutation for explosive atmospheres; (2) improved radio filtration with radio noise practically eliminated; (3) lighter weight; (4) high altitude operation problems reduced; (5) less maintenance because brushes, commutators and sliprings are eliminated and (6) improved reliability, particularly for standby equipment.

Brushless Alternator Design

The schematic diagram of Fig. 1 shows a simple brushless alternator. With dc current applied to the exciter field winding, F1-F2, the solid frame becomes permanently magnetized to a degree sufficient for voltage build-up even after prolonged shut-down.

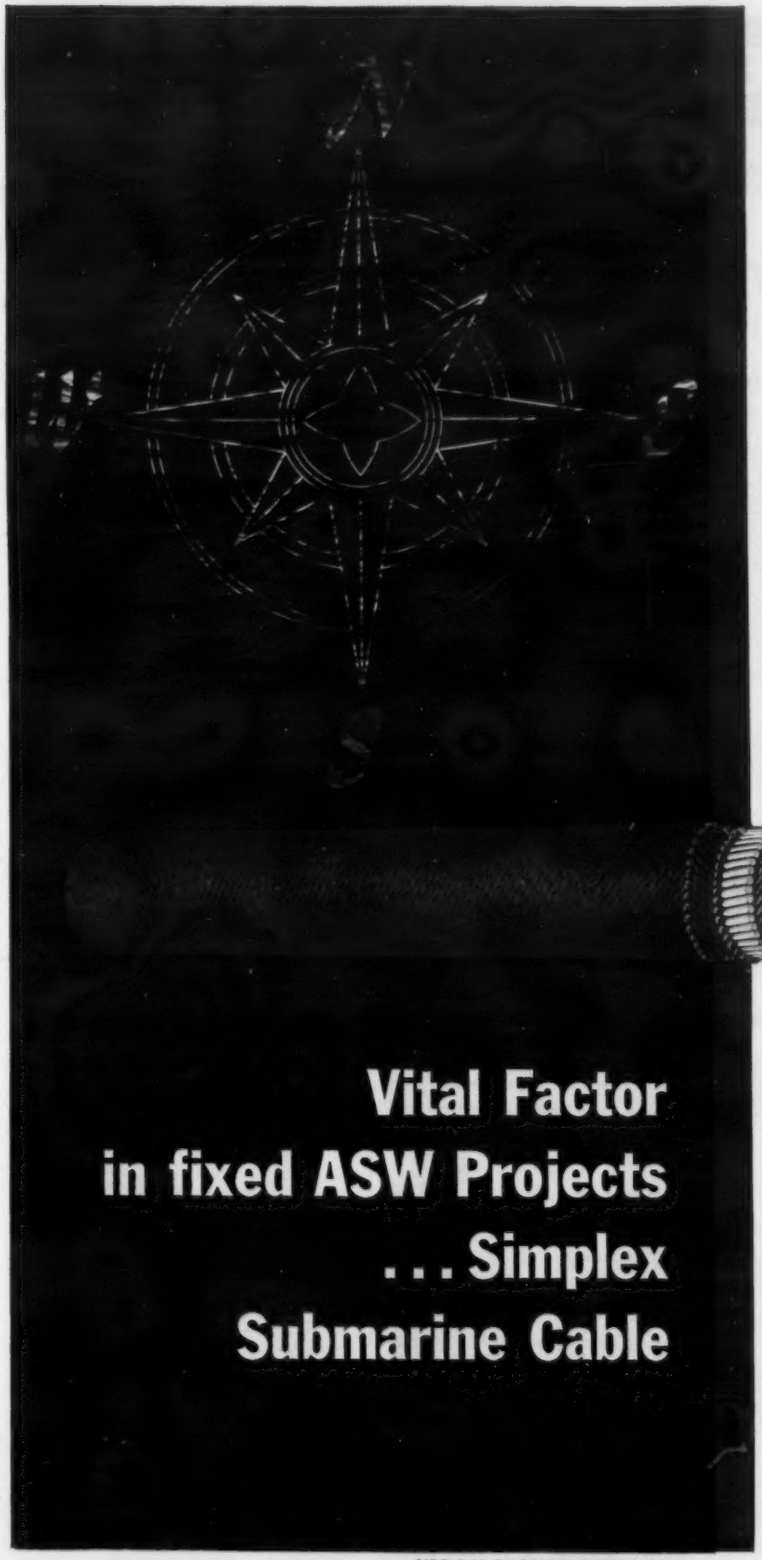
When the generator is operated at or near its rated speed this residual magnetism causes an ac 3-phase voltage to be generated in the exciter armature winding. This voltage causes currents to flow from the exciter winding through diodes D-1, D2 and D3 (which form a 3-phase half-wave bridge rectifier) and through the alternator field winding in the direction indicated by the arrows. This alternator field current magnetizes the rotating alternator field magnet, which in turn induces voltage in the alternator armature (stator) windings supplying power to the load.

Although the schematic shows a single-phase alternator, the alternator armature windings might equally well be two- or three-phase. Rotating parts, all on a common shaft, are the exciter armature, the diodes and the alternator field (Fig. 2). Note that no electrical contacts are required between the rotor and stator circuits.

Since a separate source of voltage for the exciter field may not be available or desirable, means must be found to make the alternator self-excited. To accomplish this, a second rectifier assembly is connected to the alternator output leads. Its dc output voltage is then applied to the exciter field. Voltage regulating networks are also added to the exciter circuit.

For self-starting motor-generator sets or other situations where an external source of dc voltage for the exciter field is available, Fig. 1 might be the best circuit to use, for a variety of reasons.

FOR MORE INFORMATION CIRCLE 240 ON READER-SERVICE CARD



For fixed U. S. undersea coastal defense projects since World War II, Simplex Submarine Cable Division has provided both power and communications cable. More than one quarter million miles of conductor contained in over 5,000 miles of cable represent Simplex's contributions to the ASW effort.

But there's a lot more to the exciting story of Simplex Submarine Cable Division capabilities. Read it in the new illustrated brochure, free on request. Address inquiries to: General Manager, Submarine Cable Division.

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CIRCLE 81 ON READER-SERVICE CARD

vernistat design report

information on vernistat® potentiometers for design engineers

HIGH LINEARITY, LOW QUADRATURE, HIGH INPUT-OUTPUT IMPEDANCE RATIO, AND WE'RE THINKING SMALL!

The new Size 9 Vernistat® a.c. Potentiometer follows the trend to the compact! It has small dimensions but considerable stature. And biggest news of all, there's been a major price shrinkage! The reason?—new design and improved manufacturing techniques.

Specifications of the Size 9 Vernistat prove that good things do come in small packages. These new units provide high input-low output impedance ratios, low quadrature (phase shift), ten-turn accuracy with continuous rotation, and a host of other features. To put numbers to these claims: the Size 9 has an input impedance of 60K ohms with an output impedance of only 160 ohms; 0.2 mV/V quadrature; ±0.05% terminal conformity; and 0.01% resolution. Size is important here too — only 0.875 inches in diameter and 1.85 inches long.

Those of you who previously have been kept out of the Vernistat fold by size and price considerations can do great things with this new model. Why don't you investigate soon the improved results that Vernistats can give to the analog, servo and computer circuits you design.

Descriptions of how to achieve greater accuracy, higher reliability, and significant size and weight reductions of your equipment are yours for the asking. Write today for complete literature.

WHAT IS A VERNISTAT?

The Vernistat is a combination of a tapped auto-transformer and an interpolating resistance element. This combination results in a multi-turn continuous rotation a.c. potentiometer. It provides high accuracy and inherent reliability, and a series of unique electrical and mechanical characteristics unobtainable with any other potentiometer.

The Vernistat is an excellent component for precision servo and computer circuits where high accuracy combined with reliability is required. The Vernistat may be used with great advantage as a:

Servo Follow-up Element — where high gain and accurate response are important, the Vernistat provides high loaded terminal linearity, high resolution, and low quadrature.

Computer Element — the Vernistat may be simply cascaded to perform function multiplication, because of its high input-output impedance ratio.

Data Transmitter — or readout device in analog equipment such as navigation systems, fire control computers, and Doppler radar systems.

vernistat division
PERKIN-ELMER CORPORATION
768 Main Avenue, Norwalk, Connecticut

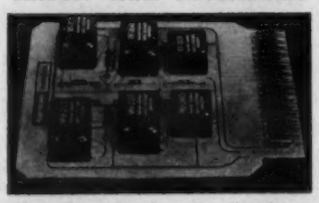
CIRCLE 82 ON READER-SERVICE CARD

4-BINARY MODULE

New Model BC 585-4 time interval counter module divides input count by any number from 9 through 16 by making bus connections on 10-pin connector. Finished module is compared with developmental breadboard model. Input is −4 to −10v pulse or step with 1 μsec rise time; output is 7.5 v with rise time of 0.1 μsec with load of 1 binary.—*Bulova R & D Laboratories, Div., Bulova Watch Co., Inc., 62-10 Woodside Ave., Woodside 77, N. Y.*

CIRCLE 241 ON READER-SERVICE CARD

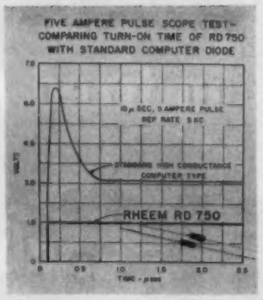
CIRCUIT CARD ASSEMBLIES



New Flexi-Card series circuit-card assemblies are factory assembled with customer-specified module assortments. Instead of each card being suitable for only one module type, each Flexicard may be specified to perform a logical system function, with an assortment of module types for economy in cabling, debugging time and cost. —*Harmon-Kardon, Inc., Data Systems Div., Plainview, L.I., N. Y.*

CIRCLE 242 ON READER-SERVICE CARD

FAST-SWITCH DIODE



New RD750 silicon diode in DO-7 configuration gives 5-to-1 improvement in conductance (1 amp at 1 volt), power dissipation of 750 mw and reverse recovery time as low as 10 nsec.—*Rheem Semiconductor Corp., 350 Ellis St., Mountain View, Calif.*

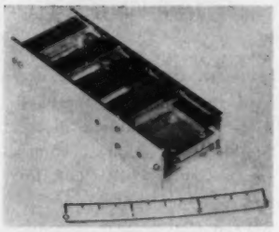
CIRCLE 243 ON READER-SERVICE CARD

OSCILLOSCOPE CAMERA

New Type 450 oscilloscope camera with interchangeable camera backs and lenses permit optional recording on Polaroid or standard films, in sizes from 4"x5" to 35mm. Synchro shutter arms scopes for single sweeps. —*Allen B. DuMont Laboratories, 750 Bloomfield Ave., Clifton, N. J.*

CIRCLE 244 ON READER-SERVICE CARD

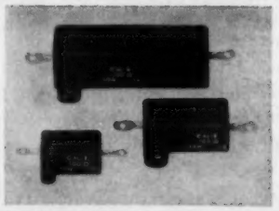
PHOTOMULTIPLIER



New photomuliplier covering range from 2 to 1500 Angstrom is also a proven ion molecule detector for space exploration. Rise time less than 5 x 10^{-9} sec with dark current less than 0.1 electron/sec referred to cathode. Bulletin 306 describes.—*The Bendix Corp., 3130 Wasson Road, Cincinnati 8, Ohio.*

CIRCLE 245 ON READER-SERVICE CARD

PRECISION POWER RESISTORS



New metal-clad miniature wirewound types MC (inductive) and MCX (noninductive) resistors mount on chassis for maximum heat dissipation in high-power heat-sink applications. Resistor element is high-pressure injection-molded to prevent air entrapment in deep-finned extruded aluminum housing. Operating temperature from —55° to 275°C with insulation strength over 1000 vac.—*California Resistor Corp., 1631 Colorado Ave., Santa Monica, Calif.*

CIRCLE 246 ON READER-SERVICE CARD

READERS AND ADVERTISERS have much to look forward to in MSD's editorial coverage for 1962. Scheduled for special "design application" treatment are: Synchros, servos and related devices; resistors and reactive components; power supplies; microwave components; commutating devices; and solid-state components.

MSD's January-February 1962 issue will highlight "solid-state components" including thin films, semiconductors, diodes, zeners, rectifiers, microcircuits and related devices, and their applications in system design. Advertisers have 'til January 10 to forward copy and plates for this important issue.

CLUTCHED SYNCHRO

Size 10 package contains electromagnetic clutch, spring return mechanism and synchro for computer applications. Return mechanism is set to ± 1 minute of electrical zero and repeats synchro position to within ± 1 min. Synchro can be rotated through 360°. Also available with pots or commutator switches.—*Astrodyne Inc.*, 121 *Clinton Rd., Caldwell, N. J.*

CIRCLE 359 ON READER-SERVICE CARD

TAPE HEAD DEMAGNETIZER

New tape head demagnetizer for removing permanent magnetism from tape recording heads reduces noise level, harmonic distortion and hum while improving signal noise ratio and insuring high frequency response. —*Microtran Company, Inc.*, 145 *East Mineola Ave., Valley Stream, N. Y.*

CIRCLE 360 ON READER-SERVICE CARD

HIGH SPEED VALVE

New 3" dia air valve opens wide in 15 msec to produce an explosive air blast. Developed for aircraft arrestor use, it also has possible application as rapid pressure release, explosive simulation or high-energy metal forming. Max operating pressure is 1500 psi.—*Research, Inc., Box* 6164, *Minneapolis* 24, *Minn.*

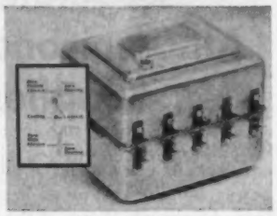
CIRCLE 361 ON READER-SERVICE CARD

MAGNETIC LATCHING RELAY

New Series AM microminiature relay for grid-space mounting uses ceramic link push-pull action to provide contact mating in either pole position. —*General Electric Specialty Control Dept., Waynesboro, Va.*

CIRCLE 362 ON READER-SERVICE CARD

INSTRUMENT HOUSINGS



New Zero deep-drawn aluminum sealed instrument housings withstand internal or external pressures of 15 psi, replace casting type housings that are heavier, more expensive and require special soldering.—*Zero Manufacturing Co.*, 1121 *Chestnut St., Burbank, Calif.*

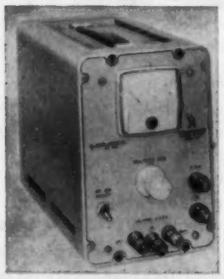
CIRCLE 363 ON READER-SERVICE CARD

PHASE-SENSITIVE VOLTMETER

New Model 302-1 all-transistor voltmeter for panel mounting in ground support equipment includes its own power supply and internal reference isolation transformer in meter package. Phase-sensitive measurement of ac signal voltages is immediate, as soon as power is applied.—*Trio Laboratories, Plainview, L. I., N.* Y.

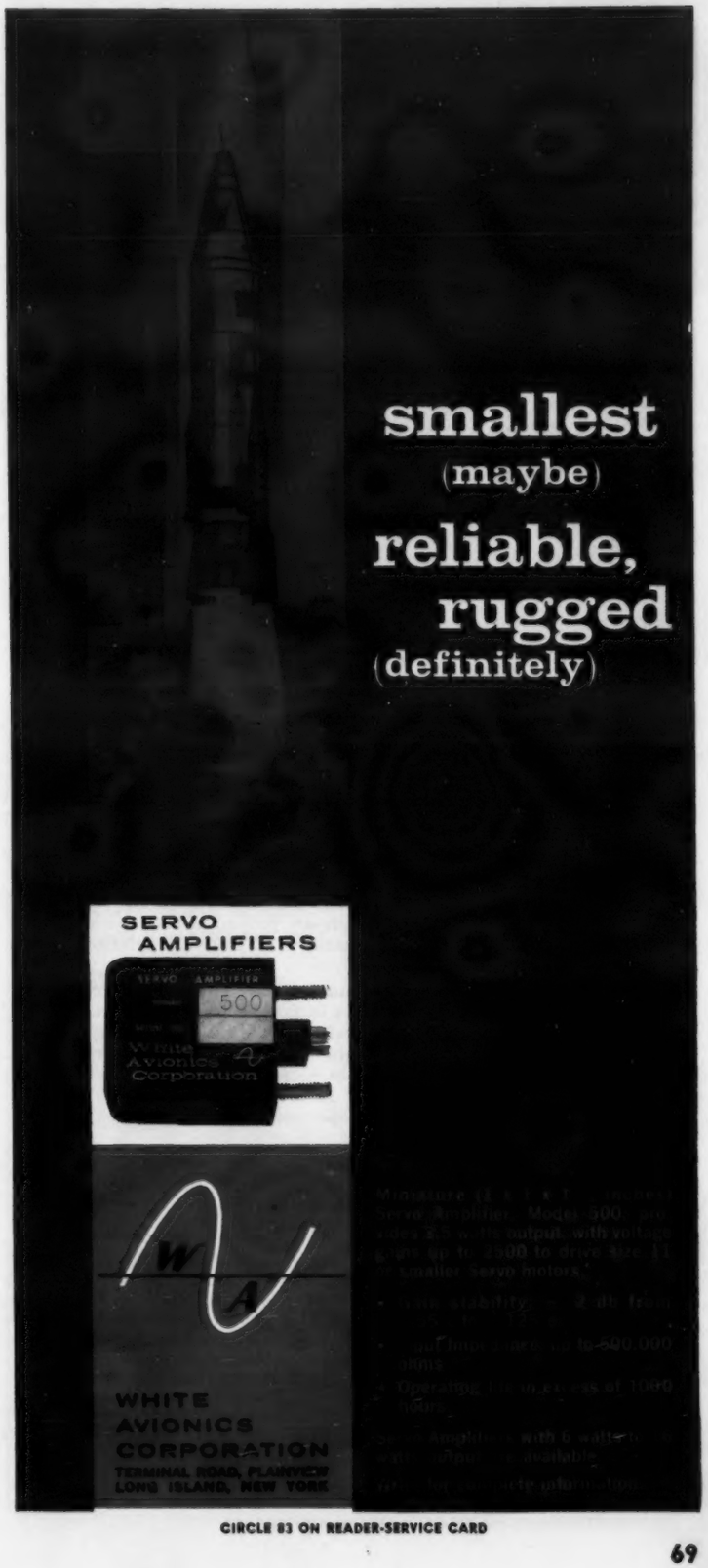
CIRCLE 247 ON READER-SERVICE CARD

ENERGY INTEGRATOR DC SUPPLY



New Praxicon® semiconductor power supplies employ a new technique for supplying regulated dc power. Switching circuitry takes power from the ac line in discrete pulses. These pulses are integrated by a fast response time regulator system to supply the load demand. The regulator system senses the load requirements and its own internal losses, controls input power by varying amplitude, width and repetition rate.—*Power Designs, Inc.*, 1700 *Shames Drive, Westbury, N. Y.*

CIRCLE 248 ON READER-SERVICE CARD

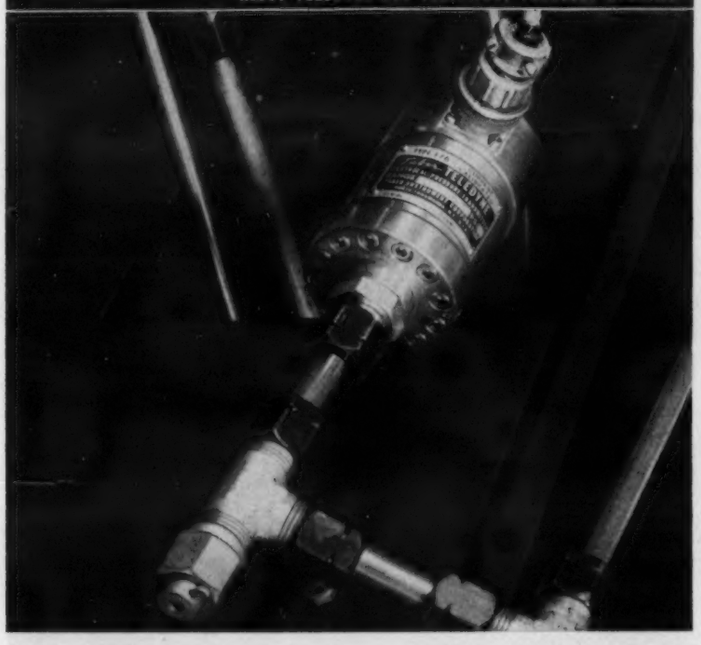


CIRCLE 83 ON READER-SERVICE CARD

Taber®

TELE-NEWS

ABOUT TELEDYNE AND TELEFLIGHT PRESSURE SYSTEMS



Taber Transducer logs 1,500,000 cycles in Pall filter tests without repair

The sensitivity, continuous performance and economical life of Taber bonded strain gage pressure transducers are proved in test operations at Aircraft Porous Media, Inc., a subsidiary of Pall Corporation, Glen Cove, N. Y.

This leading manufacturer of porous stainless filters uses Model 176 Taber Teledyne Pressure Transducers in fatigue testing pneumatic and hydraulic filter units for missiles, aircraft, and atomic submarines. During these tests, pressure pulses from zero to 10,000 psi are sensed and recorded on an oscilloscope at a rate in excess of 150 cycles per minute. Rate of pressure rise is in the range of 200,000 to 300,000 psi per second. The unit shown above has been in operation in excess of 1½ million cycles *without repair or overhaul.*

For full information on Taber Transducers (in pressure ranges from 0-50 to 0-10,000 psi) for test, ground support, and airborne applications, send this coupon attached to your letterhead.

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Send detailed information on Taber Teledyne and Teleflight bonded strain gage pressure transducers.

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CIRCLE 84 ON READER-SERVICE CARD

Regulated All Semiconductor Supplies

Sturdy mechanical design is combined with high-quality components in a new series of all semiconductor regulated power supplies operating from 105-125 v, 60-400 cps inputs. All outputs shown in the table are ±0.1% except where designated ±5% for certain larger sizes.

POWER SUPPLY SELECTOR CHART

Output Potential Range Volts		Output Current Ranges 0-¼ Amp.	0-½ Amp.	0-1 Amp.	0-2 Amps.
5-7		TMA-7	EM-7	E10M-7	E20M-7
7-10		TMA-10	EM-10	E10M-10	—
10	±5%	—	—	—	E20M-10
12	±5%	—	—	E10M-12	E20M-12
10-15		TMA-15	EM-15	—	—
15	±5%	—	—	E10M-15	—
15-20		TMA-20	EM-20	—	—
24	±5%	—	—	E10M-24	—
20-25		TMA-25	EM-25	—	—
30	±5%	—	—	E10M-30	—
25-30		TMA-30	—	—	—
30-40		E3M-40	—	—	—
40-50		E3M-50	—	—	—
50-60		E3M-60	—	—	—

Hermetically sealed silicon rectifiers, computer grade capacitors, all PNP germanium transistors and dual zener circuits are teamed in rugged construction to produce robust equipment without recourse to encapsulation. Unique eyelet-solder lug panel affords the advantages of printed circuits while retaining the reliability of point-to-point wiring . . . (*From 4-page brochure, Transistor Devices, Inc., 40 Factory St., Cedar Grove, N. J.*)

FOR THIS LITERATURE CIRCLE 249 ON READER-SERVICE CARD

For Your Library

Electronic Circuitry for Instruments and Equipment **$2.00**

by M. H. Aronson. "Comprehensive source book on instrument circuitry" this complete home-study text includes 458 multiple-choice questions (and answers). 215 illustrations, 10 tables, comprehensive index. Paperbound, 324 pages, 1957 (revised edition).

INSTRUMENTS PUBLISHING COMPANY
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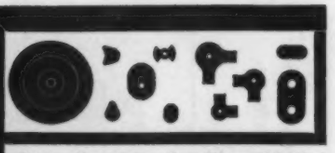

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Merely press these pre-cut forms into place, presto—a neat, clean, master layout! Dozens of shapes, hundreds of sizes, precision die-cut from pressure-sensitive black photographic tape, enable you to draft any circuit: no artistic skill required. Make changes in seconds without messy erasing.

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Special shapes (or even entire circuits or other repetitive items) die-cut to your specs in only 10 days!

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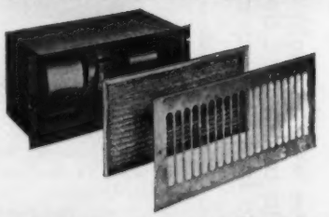
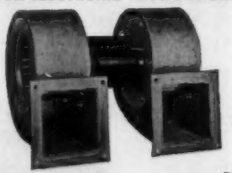
CIRCLE 85 ON READER-SERVICE CARD

McLEAN



FANS-BLOWERS

FOR ELECTRONIC APPLICATIONS



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TWX Princeton, New Jersey 636

CIRCLE 86 ON READER-SERVICE CARD

MILITARY SYSTEMS DESIGN

LOW VOLTAGE SUPPLY

New solidstate super-regulated dc power supply Model PS110, for test and operation of transistorized circuits, strain gages, etc., has output of 15v adjustable ± 10%, load current of 400 ma with regulation of .002%. Miniaturized to 2.5" x 8" x 5", weight 5.5 lbs.—*Dynex Industries, Inc.*, 170 *Eileen Way, Syosset, N. Y.*

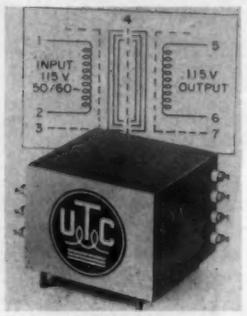
CIRCLE 250 ON READER-SERVICE CARD

FIBER-OPTIC CRT

New Type 2160 cathode ray tube with fiber optic face plate has over 6 million fibers in 1-7/16" diameter. Designed for flying spot scanner photographic printing and for coupling to electronic devices using fiber optical inputs.—*Allen B. DuMont Laboratories, 750 Bloomfield Ave., Clifton, N. J.*

CIRCLE 251 ON READER-SERVICE CARD

ISOLATION TRANSFORMER

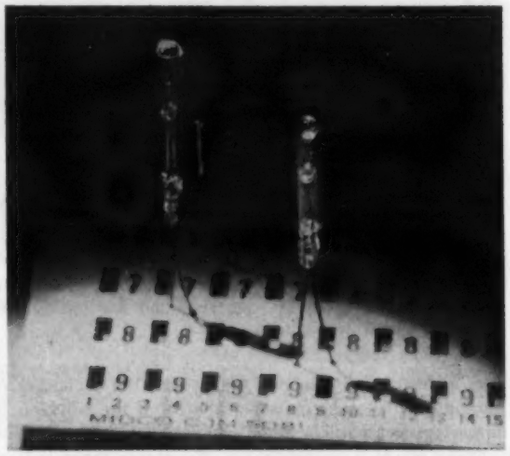


New ultrashielded isolation transformer MIT-15 for ciritical circuits requiring ultimate in power line equipment simulates battery operation. Power rating of the HIT-15 is 150 watts industrial, 120 watts to MIL-T-27A. Effective coupling between primary and secondary windings is less than 0.1 $\mu\mu$f, with shields individually terminated to allow maximum flexibility in circuit design.—*United Transformer Corp., 150 Varick St., New York 13, N. Y.*

CIRCLE 252 ON READER-SERVICE CARD

High Voltage Photo Diodes

New silicon diode photosensors for readout of punched card and tape are capable of handling up to 20 v reverse breakdown voltage with under 10 μamp of current, permitting the use of direct coupled circuitry. Previous devices have been limited to about 2 volts; had to use costly transformers to convert light information into usable pulses and sinusoidal waves. Optimization of the diffusion process of diode production is credited with the high-voltage capability of the new photosensors.



The new photosensors, a development of the Philco Lansdale Division, Lansdale, Penna., are hermetically sealed in glass envelopes .080" diameter. Two types are available; one type with the active area positioned parallel to longitudinal axis of diode for side-reading, the other with the active area perpendicular to the axis with an end lens for frontal exposure.

Although designed primarily for punched card and tape readout, other applications are teletypewriter coding, signal switching, photographic sensing and control, optical scanning and sound pickup. Spectral response covers the range from 5000 to 11000 angstroms, peaking at 9500 angstroms. Operating temperatures range from —65° to 150°C and the component withstands storage temperatures to 175°C.

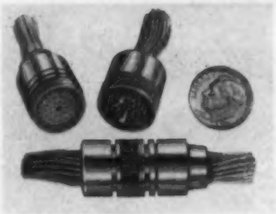
FOR THIS LITERATURE CIRCLE 253 ON READER-SERVICE CARD

HIGHSPEED 16MM CAMERA

New FASTAX 16-mm camera has a variable speed range controlled by servo permitting rapid acceleration and regulated operational velocity within ±4% of preselected rate. Improved resolution, 1200 ft capacity, timing markers, electrical interlocks, speed indicator and footage counter and ability to use most existing FASTAX bayonet-type lenses are features.—*Wollensak Optical Company, 850 Hudson Ave., Rochester 21, N. Y.*

FOR THIS LITERATURE CIRCLE 254 ON READER-SERVICE CARD

MICROMIN MULTIPIN CONNECTORS



New Microminiature multi-pin connectors meeting test requirements of MIL-C-26636 utilize key pin to eliminate mis-mating, are available in 7, 19 and 47 contact sizes.—*Omega Precision, Inc., 757 N. Coney Ave., Azusa, Calif.*

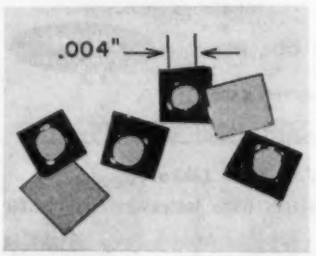
CIRCLE 255 ON READER-SERVICE CARD

DC TO SINEWAVE INVERTER

New hermetically sealed 100VA Model K33 static inverter for driving 115v 400 cps 3-phase motors, gyros and magnetic amplifiers from 28v dc features self-protection from line transients, overloads and reversal of input polarity. All solid state circuitry; is tested 100% for compliance to MIL-E-7894 ASG (line spikes of 60v peak) and environmental specs.—*Arnold Magnetics Corp., 6050 W. Jefferson Blvd., Los Angeles 16, Calif.*

CIRCLE 351 ON READER-SERVICE CARD

MESA DIODE DICE



Two standard types of silicon mesa diode dice are the MSC-1, ultra-fast computer diode, with <2 nsec recovery, <2 pf capacitance, >75v PIV; and general purpose MSC-2 with PIV >300v, <,010 μamp leakage. Dice are surface passivated with typical mesa only 4 mils diameter, exceed MIL-S-19500B without additional sealing.—*Micro-Semiconductor Corp., 11250 Playa Court, Culver City, Calif.*

CIRCLE 352 ON READER-SERVICE CARD

(*Continued on page 73*)

Low Frequency HIGH Q COILS

UTC

PIONEERS IN MINIATURIZATION

Hermetically Sealed
Manufactured & Guaranteed to
MIL-T-27A

MQL SERIES of laminated Hipermalloy coils were specifically designed for high Q at low frequencies. The unique structure employed provides exceptional Q and stability. Inductance values are laboratory adjusted to 2% tolerance at 1 volt, 60 cycles. Stability with voltage is excellent. Temperature stability is exceptional from −55°C to +105°C. A hum reducing lamination structure plus heavy Hipermalloy shielding provide very low hum pickup. Two identical windings brought out to four terminals permit series, parallel, center tapped, or transformer type connections.

Type No.	Series Henries (0 DC)	Parallel Henries (0 DC)	Series DCRΩ ±20%
MQL-0	1	.25	5
MQL-1	10	2.5	50
MQL-2	20	5	82
MQL-3	200	50	820
MQL-4	400	100	2100
MQL-5 (For 60 cycles and lower)	2500	625	13K

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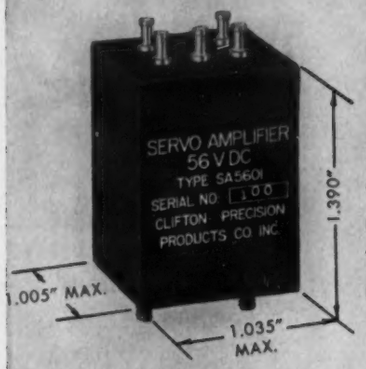
CIRCLE 87 ON READER-SERVICE CARD

High Fidelity in SERVO Amplifiers?

ACTUAL SIZE



YES! Look at these specifications

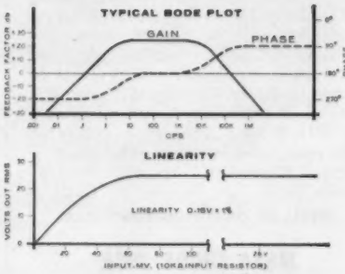
POWER OUTPUT 5W
± 3db 10 cps–30 kc
< 1% THD AT 2 WATTS
FEEDBACK > 20db
GAIN MARGIN > 20db
PHASE MARGIN > 90°
TEMP. RANGE −55+125°C
EFFICIENCY > 65%

VOLUME = 1¾ CUBIC INCHES

CPPC's new 5 watt servo amplifier provides a unique combination of exceptional stability and miniature size. Built around a DC amplifier with high frequency cutoff above 30 kcps, the SA 5601 provides uniform response over its full operating range. With a 10 kΩ input resistor the SA 5601 yields a voltage gain of 54 ± 1 db from −55° to + 125°C with all signal levels below saturation, and supply voltage of 56 ± 3 volts. Idling power is under 1 watt.

Designed to drive any size 8, 10 or 11 servo motor with a 26 volt control-phase rating, the SA 5601 is available off the shelf with stud or screw mounting. A regulated supply of the 56 VDC power required for the SA 5601 operating from 115 V 400 ~ and providing a 26 V AC tap for motor and synchro excitation is available in a similar package.

For information phone or write: Area 215 MAdison 2-1000, TWX LNSDWN, Pa. 1122(U)—or our Representatives.



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Strain Gage Instrumentation $2.00

edited by Aronson and Nelson ". . . a practical text . . . covers fundamentals, basic bridge circuits, typical applications, and surveys typical commercial instruments which use or are used with strain gages." Paper 110 pages, illustrated, indexed by company, author, and subject, 1958.

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845-Ridge Avenue
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Wirewound and Conductive Plastic Pots

Two-watt single-turn precision potentiometers in ½" miniature and ⅞" sine-cosine wire-wound models have been added to the line of miniature wire-wound precision pots available from Fairchild Controls Corporation, a subsidiary of the Fairchild Camera and Instrument Corporation, with offices at 225 Park Ave., Hicksville, L. I., N. Y. and Los Angeles, Calif.

The ½" unit (Fig. 1) features ±0.5% linearity standard, dielectric strength of 1,000 v rms, the capability of ganging up to eight units per shaft and the addition of three taps per cup. A single cup weighs 14 grams, with 8 grams for each additional cup. Resistance range is from 100 to 15,000 ohms, all meeting MIL-R-12934 requirements.

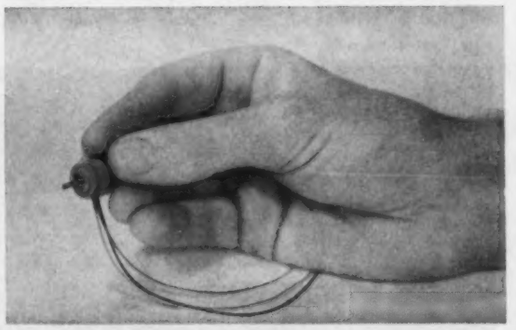

FIG. 1. MINIATURE HALF-INCH Precision Pot is new wirewound gangable and tappable unit for missile and aircraft control applications.

The ⅞" (751) Sine-cosine potentiometer, in the same resistance ranges, provides standard conformity tolerance of 1.2% (pk-to-pk voltage) on a single cup, with 1.5% conformity on multiple cup assemblies. Maximum weight of a single cup is 0.9 oz, with 0.5 oz for each additional cup.

Fairchild Controls Corporation also has announced

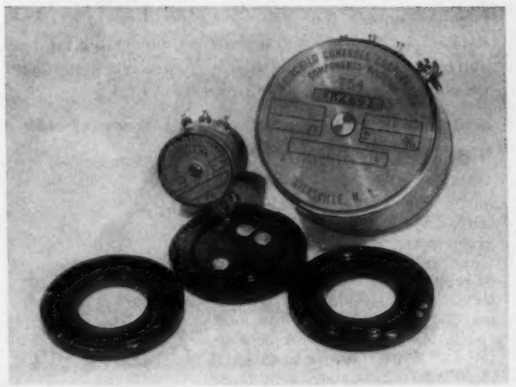

FIG. 2. CONDUCTIVE PLASTIC "Fairite" Series potentiometers in sizes from ⅞" to 5" diameters mark Fairchild Control's entry in conductive plastic pot field.

TOTAL TEMPERATURE PROBES PITOT-STATIC TUBES

ILLUSTRATED MODELS

MODEL 850 Meets Mach 3 requirements of MIL-P-25757A (USAF).

MODEL 103 Mach 5 total temperature probe can be used to temperatures of 1500 C°.

MODEL 101 Mach 3 total temperature probe. Meets requirements of MIL-P-25726 (USAF).

MODEL 102 Mach 3 Deiced total temperature probe. Accurately measures total temperature during deicing.

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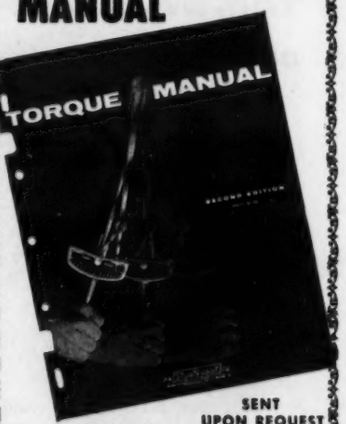
"TORQUE WRENCH" MANUAL



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CM8-680 — famed for long life...now specified for military equipment!

ULTRA-MINIATURE LAMPS
MILITARY STANDARDS NUMBERS

Midget Flange Base

MS-24515-682	MS-24515-682AS-15
MS-24515-685	MS-24515-685AS-15
MS-24515-714	MS-24515-714AS-15
MS-24515-718	MS-24515-718AS-15

Unbased—Wire Terminals

MS-24367-680	MS-24367-680AS-15
MS-24367-683	MS-24367-683AS-15
MS-24367-713	MS-24367-713AS-15
MS-24367-715	MS-24367-715AS-15

Note: Chicago Miniature's lamps are preceded by prefix CM8, e.g., MS-24367-715AS-15 is Chicago Miniature's CM8-715AS-15.

Computations, based on accelerated life tests, indicate that this lamp will burn for 1,000,000,000 years! Unfortunately none of us will be around to prove it! However, we do know that the CM8-680 series lamps that were originated in our laboratories, are widely recognized for their unfailing reliability and exceptionally long life.

Because of these qualities, the CM8-680 series is now specified for military use (MS24367 and MS24515). The Chicago Miniature Lamp Works is the prime source for this type of lamp.

Suppliers to military services, producing equipment that incorporates ultra-miniature lamps, can be sure of compliance to specifications by ordering these lamps by these MS numbers.

For complete specifications on these and other ultra-miniature lamps—

WRITE FOR BULLETIN 1106-R

CHICAGO MINIATURE LAMP WORKS
1553 No. Ogden Avenue, Chicago 10, Illinois
CIRCLE 92 ON READER-SERVICE CARD

Continued from page 68

their entrance into the conductive plastic potentiometer field with a new line of "Fairite" models in sizes from 7/8" to 5" diameter and resistances from 2000 ohms to 50K ohms (Fig. 2). Almost infinite resolution (less than .005°), high reliability under extremes of environment, and minimum life to over 10 million cycles at 600 rpm, are featured. The geometry of the Fairite conductive plastic track can be varied to obtain optimum functional conformity and silver terminals are molded in for low end-loss connections. The conductive plastic element is also co-molded with the insulating plastic base for greatest mechanical strength, resistance stability and exclusion of humidity effects. Power dissipation is 2 watts at 20°C, with a 300-400 ppm negative temperature coefficient.

FOR THIS LITERATURE CIRCLE 353 ON READER-SERVICE CARD

SIZE 9 VERNISTAT

High input to output impedance ratios, high terminal linearity and excellent reliability of the Vernistat ac potentiometer is now available in a new size 9 model. Characteristics include 30,000 ohm input impedance, 160 ohm output impedance, and a 0.2 mv/v quadrature at 400 cps. Terminal linearity is ± .05%.—*Vernistat Div., Perkin-Elmer Corporation, Norwalk, Conn.*

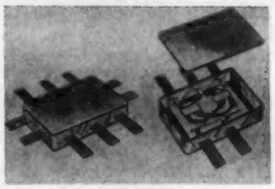
FOR THIS LITERATURE CIRCLE 354 ON READER-SERVICE CARD

AUTOMATIC REGULATORS

New 50/60 cycle, 3-phase regulators give constant output voltage with no waveform distortion. 240 and 480 kva ratings with output adjustable in 440-480 v range. 4-page bulletin S461-EMHC describes circuit and operation.—*The Superior Electric Co., Dept. EMHC, Bristol, Conn.*

CIRCLE 356 ON READER-SERVICE CARD

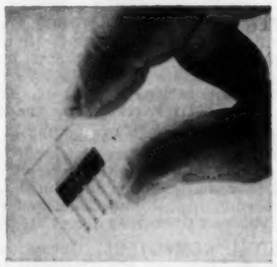
MICROELECTRONICS PACKAGE



New flat rectangular enclosure for multi-element devices, thin-film and solid-state circuits is being developed with a glass-to-metal hermetic seal and metal base plate for internal device mounting which in turn mounts on external heat sink. Conforms to printed circuit, micro-module or stacked mounting techniques.—*Wm. F. Long, Mfg., Microelectronics Dept., Lansdale Div., Philco Corporation, Lansdale, Pa.*

CIRCLE 357 ON READER-SERVICE CARD

THIN FILM NETWORKS



New hermetically-sealed, thin film, tin-oxide resistor networks meeting MIL-R-10509C have basic resistivity of 100 ohms per square and values range from 50 ohms to 4 megohms. T/C is ± 50 ppm/°C in production runs, lower on special order. Any type circuit to customer specifications.—*Intellux, Inc., 30 So. Salsipuedes St., Santa Barbara, Calif.*

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Continued on page 79

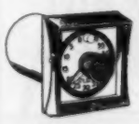
Precision in timing Accuracy in setting for GROUND SUPPORT EQUIPMENT

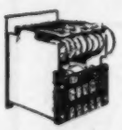
20 TURN MICROMETER DIAL

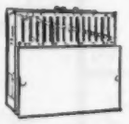
The EAGLE Microflex Timer provides unequaled accuracy in closing or opening a circuit. An easy-to-read 20 turn double micrometer dial speeds the selection of new settings over full 7200° range and permits a one-glance check of previously set intervals.

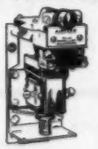
- PIN-POINT ACCURACY is possible with 1200 conveniently spaced dial markings. No guessing at in-between points. Accuracy maintained by patented pinion and threaded axle.
- 9 DIFFERENT ACTIONS are available for each of 3 SPST 15 ampere contacts which can be selected according to circuit requirements.
- PLUG-IN COMPONENTS allow rapid replacement of timers. Large capacity contacts eliminate additional load relays.

OTHER POPULAR HIGH QUALITY EAGLE TIME-COUNT CONTROLS


CYCLE-FLEX PLUG-IN TIMER


CAM TIMERS


MULTI-CIRCUIT TIMERS


TIME DELAY RELAYS

For more details on the Microflex Timer, write for free bulletin 110, or contact your local Eagle Representative listed in Thomas Register or Phone Directories in 25 principal cities.

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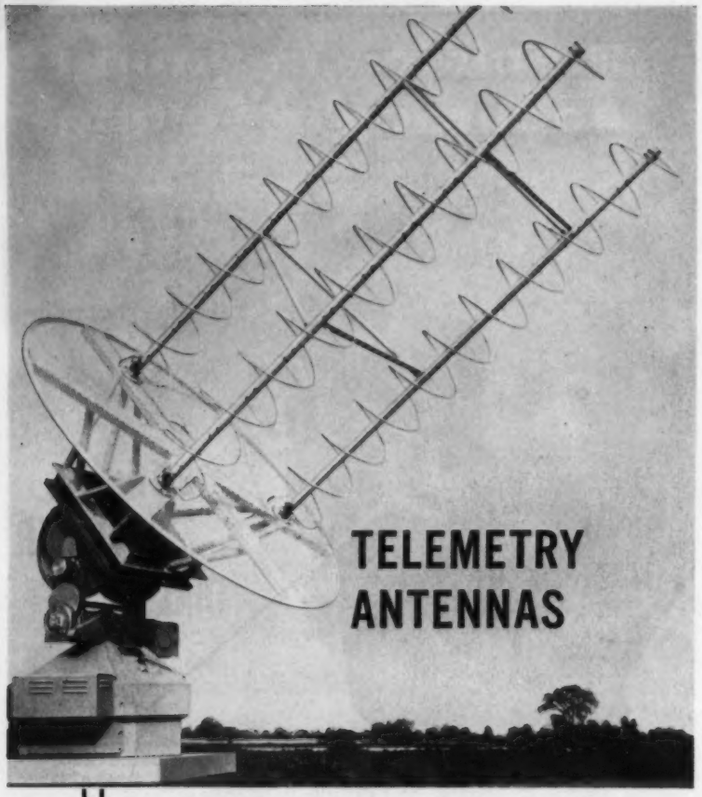

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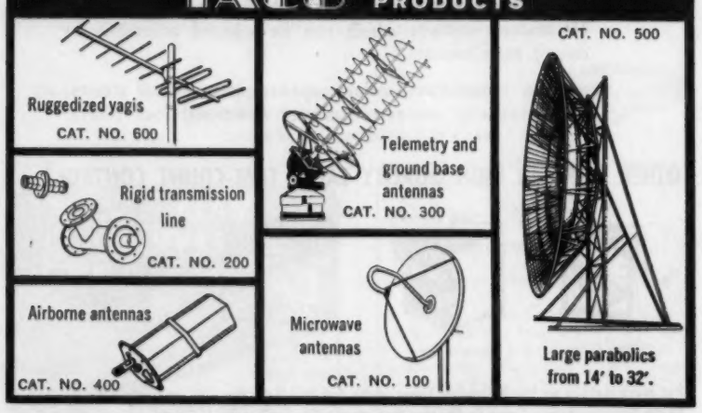

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MSD new literature

SERVO AMPLIFIER Applications in typical servo systems are described in new 4-page bulletin TB1030.—Melcor Electronics Corp., 48 Toledo St., Farmingdale, N. Y.
FOR THIS LITERATURE CIRCLE 256 ON READER-SERVICE CARD

PRECISION ACCELEROMETERS for aircraft and missile flight and fire control systems are described in new 22-page accelerometer catalog giving detailed data on five typical seismic models.—Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.
FOR THIS LITERATURE CIRCLE 257 ON READER-SERVICE CARD

GYRO-TEST TURNTABLE, Model T900 using air bearings, is described in new 4-page brochure.—Dunn Engineering Corp., 225 O'Brien Highway, Cambridge 41, Mass.
FOR THIS LITERATURE CIRCLE 258 ON READER-SERVICE CARD

SYNCHROS, including differential transmitters, receivers, control transformers and transmitters, are described with performance data in new 2-page bulletin ST-61-2.—Ford Instrument Co., Div. of Sperry Rand Corp., 31-10 Thomson Ave., Long Island City 1, N. Y.
FOR THIS LITERATURE CIRCLE 259 ON READER-SERVICE CARD

SERVO-POTENTIOMETERS in sizes 9, 16 and 20 are described in three 2-page eem file data sheets.—Hoffman Electronics Corp., 3761 So. Hill St., Los Angeles 54, Calif.
FOR THIS LITERATURE CIRCLE 260 ON READER-SERVICE CARD

BRUSHLESS SYNCHRO which eliminates slip ring and brush assemblies and substitutes a rotary injection transformer in which the primary and secondary windings are made a rigid integral part of the stator and rotor assemblies, is described in new 4-page bulletin.—Harosyn Servo Controls Inc., West Chester, Pa.
FOR THIS LITERATURE CIRCLE 261 ON READER-SERVICE CARD

DYNAMIC TORQUEMETER with interchangeable sensors are described in new 2-page bulletin 601.—Rotiform Co., 1509 Colorado Ave., Santa Monica, Calif.
FOR THIS LITERATURE CIRCLE 262 ON READER-SERVICE CARD

SYNCHRO STANDARD which simulates the output of a Master Synchro Transmitter for the testing of synchro components to accuracy of 10 ppm is described in 2-page brochure.—Gertsch Products, Inc., 3211 S. La Cienega Blvd., Los Angeles 16, Calif.
FOR THIS LITERATURE CIRCLE 263 ON READER-SERVICE CARD

INTEGRATED SERVO-MOTOR package comprising hydraulic motor, servo valve and internal relief valves in one housing is described in new 4-page bulletin A5261.—Aero Hydraulics Division of Vickers Inc., Div. of Sperry Rand Corporation, Detroit 32, Mich.
FOR THIS LITERATURE CIRCLE 264 ON READER-SERVICE CARD

CLOCK PULSE Generator plug-in module, type 2011 CL, is a 5 mc transistorized variable frequency oscillator plug-in of the multivibrator type variable from 0.2 μsec to 250 μsec. is described in 2-page bulletin 60-R.—Rese Engineering, Inc., A and Courtland Sts., Philadelphia 20, Pa.
FOR THIS LITERATURE CIRCLE 265 ON READER-SERVICE CARD

DIGITAL COMPUTERS, Operation, features, applications and specifications are discussed in 4-page bulletin "CVI-27".—General Electric Co., Light Military Electronics Dept., Armament and Control Section, 600 Main St., Johnson City, N. Y.
FOR THIS LITERATURE CIRCLE 266 ON READER-SERVICE CARD

AUTOMATIC CHECKOUT system performance of ROBOTESTER is described in 12-page brochure.—Lavoie Labs., Inc., Morganville, N. J.
FOR THIS LITERATURE CIRCLE 267 ON READER-SERVICE CARD

ULTRASONIC DOPPLER Airborne system giving precise measurements of rate of descent at touchdown is described in 2-page bulletin ACT 7.—R. and D. Lab., Gulton Industries, 212 Durham Ave., Metuchen, N. J.
FOR THIS LITERATURE CIRCLE 268 ON READER-SERVICE CARD

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TO CONTROL THE TEMPERATURE OF CRYSTALS AND OTHER TEMPERATURE SENSITIVE COMPONENTS

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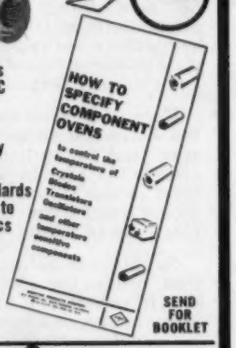

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- **Pulse Output Possible**

For testing and measurement of gyro torquers, zener, reference diodes, magnetic components, other current sensitive devices.

- **Current Range is 0.1 μa to 150 ma**
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In use by leading companies for gyro torquer supply, component reliability testing, calibration, reference zener testing.

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PROGRAMMER-COMPARATOR. Type GE PAC "200," new automatic test equipment for rapid aircraft equipment testing is described in new 4-page bulletin LMEJ 4643.—LMED General Electric Co., 600 Main St., Johnson City, N. Y.

FOR THIS LITERATURE CIRCLE 269 ON READER-SERVICE CARD

INFORMATION DISPLAY System using electronic visual systems for command control centers is described in new 4-page bulletin.—Kollsman Instrument Corp., Elmhurst 73, N. Y.

FOR THIS LITERATURE CIRCLE 270 ON READER-SERVICE CARD

MAGNETIC DETECTOR Test Set, portable, self-powered unit designed to provide rapid, economical flux-gate field testing is described in new 2-page data sheet.—Kearfott Div., General Precision, Inc., Little Falls, N. J.

FOR THIS LITERATURE CIRCLE 271 ON READER-SERVICE CARD

RADAR TEST Set for X, Ku and C bands is discussed in 6-page bulletin W104A.—Kearfott Div., General Precision, Inc., Little Falls, N. J.

FOR THIS LITERATURE CIRCLE 272 ON READER-SERVICE CARD

CAPACITOR AUTOMATIC TEST Set Type #61 measures tantalum and electrolytic types 0.1 μf to 11,000 μf range at 0.5 v rms, 120 cps. Details are described in 2-page bulletin 61-03.—Barnes Development Co., 213 West Baltimore Ave., Lansdowne, Pa.

FOR THIS LITERATURE CIRCLE 273 ON READER-SERVICE CARD

RADIO INTERFERENCE Measuring instrumentation system NM-62A is described in 2-page catalog sheet.—Stoddart Aircraft Radio Co., Inc., 6644 Santa Monica Blvd., Hollywood 38, Calif.

FOR THIS LITERATURE CIRCLE 274 ON READER-SERVICE CARD

PUNCHED CARD Sensors for simultaneously and statically reading entire standard punched cards are described in 6-page folder.—Taurus Corp., Academy Hill, Lambertville, N. J.

FOR THIS LITERATURE CIRCLE 275 ON READER-SERVICE CARD

"TRANSISTOR NOISE, A Practical Approach to," is title of new 2-page technical report on quantitative analysis of transistor noise, available on request.—Quan-Tech Laboratories, Inc. of Boonton, N. J.

FOR THIS LITERATURE CIRCLE 276 ON READER-SERVICE CARD

BAND PASS Telemetry Filters for the replacement of conventional filters in telemetering applications are described in catalog sheet.—PCA Electronics, Inc., 16799 Schoenborn St., Sepulveda, Calif.

FOR THIS LITERATURE CIRCLE 277 ON READER-SERVICE CARD

RADIO RELAY Systems for Military and government agencies are described in new 32-page Microwave Communications booklet.—Motorola Inc., Communications and Industrial Electronics Div., 4501 W. Augusta Blvd., Chicago 51, Ill.

FOR THIS LITERATURE CIRCLE 278 ON READER-SERVICE CARD

PCM TELEMETRY from Hollman sled, Titan and Minuteman missiles are described and information on reliability, bi-level programming, inputs for processing, inputs for control and synchronization, and outputs of new Model 1323 PCM telemetering system are given in new 8-page brochure.—PCM Brochure, Radiation Incorporated, Melbourne, Fla.

FOR THIS LITERATURE CIRCLE 279 ON READER-SERVICE CARD

TEST Instruments in ready wired and kit form are described in new 28-page catalog.—EICO Electronic Instrument Co., Inc., 33-00 Northern Blvd., Long Island City 1, N. Y.

FOR THIS LITERATURE CIRCLE 280 ON READER-SERVICE CARD

TEST CHAMBERS for Environmental Testing are described in 16 page catalog.—Environmental Equipment Corp., 369 Linden St., Brooklyn, N. Y.

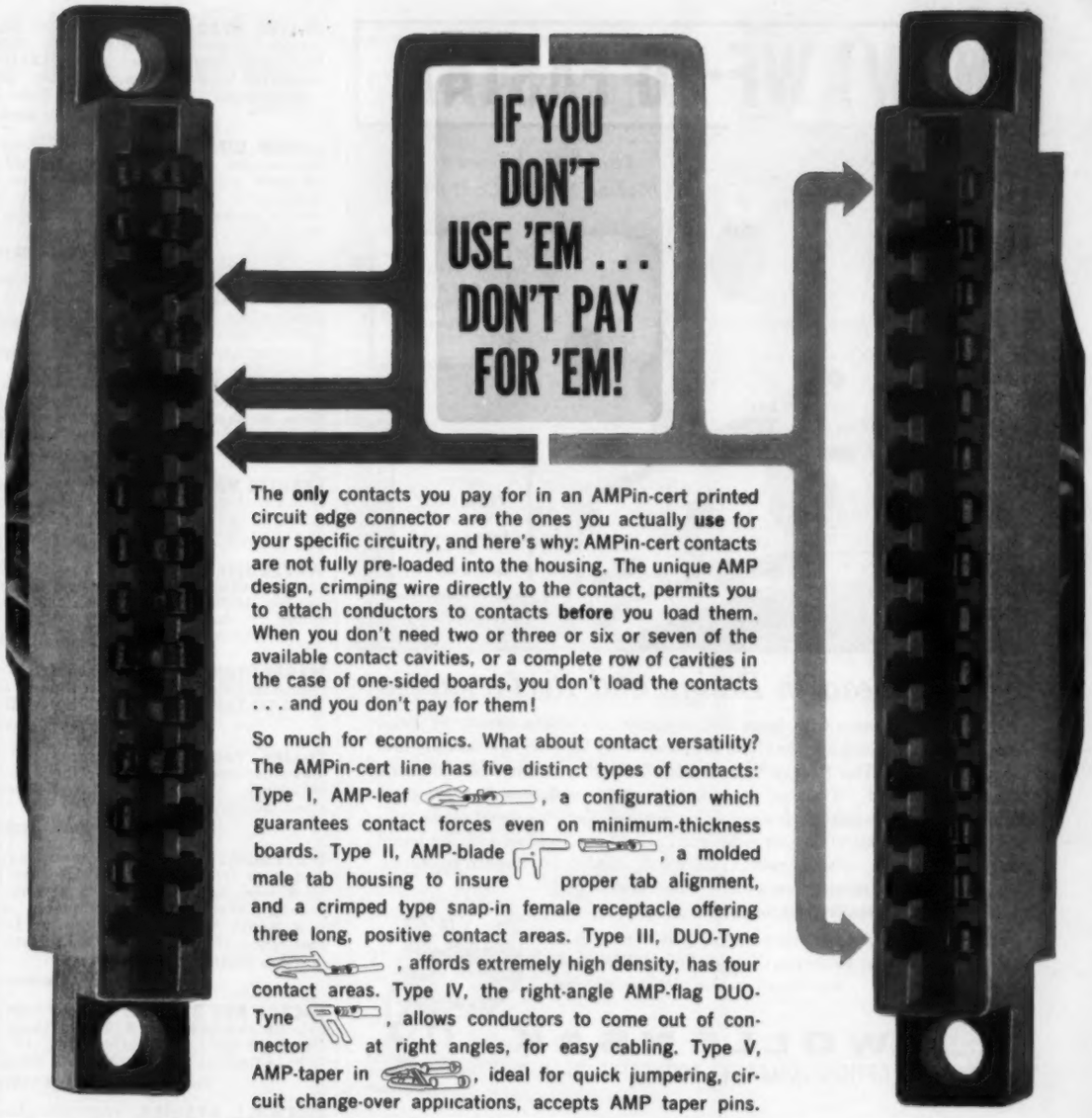
FOR THIS LITERATURE CIRCLE 281 ON READER-SERVICE CARD

MINIATURE VACUUM TUBE characteristics for 142 types used in military and industrial applications are listed in new 12-page booklet.—Raytheon Component, Industrial Components Div., 55 Chapel St., Newton 58, Mass.

FOR THIS LITERATURE CIRCLE 282 ON READER-SERVICE CARD

PIEZOELECTRIC devices, including new "spark pump," are described in new 16-page booklet. Tables give conversion characteristics of different materials.—James Mahoney, Clevite Electronic Components, Bedford, Ohio.

FOR THIS LITERATURE CIRCLE 283 ON READER-SERVICE CARD



The **only** contacts you pay for in an AMPin-cert printed circuit edge connector are the ones you actually **use** for your specific circuitry, and here's why: AMPin-cert contacts are not fully pre-loaded into the housing. The unique AMP design, crimping wire directly to the contact, permits you to attach conductors to contacts **before** you load them. When you don't need two or three or six or seven of the available contact cavities, or a complete row of cavities in the case of one-sided boards, you don't load the contacts . . . and you don't pay for them!

So much for economics. What about contact versatility? The AMPin-cert line has five distinct types of contacts: Type I, AMP-leaf, a configuration which guarantees contact forces even on minimum-thickness boards. Type II, AMP-blade, a molded male tab housing to insure proper tab alignment, and a crimped type snap-in female receptacle offering three long, positive contact areas. Type III, DUO-Tyne, affords extremely high density, has four contact areas. Type IV, the right-angle AMP-flag DUO-Tyne, allows conductors to come out of connector at right angles, for easy cabling. Type V, AMP-taper in, ideal for quick jumpering, circuit change-over applications, accepts AMP taper pins.

Quality? AMPin-cert is quality, in the contacts and the housings:

- Contacts are phosphor bronze, gold over nickel plating
- Contacts accept single, multiple leads, and "snap-in" the housing without insertion tools
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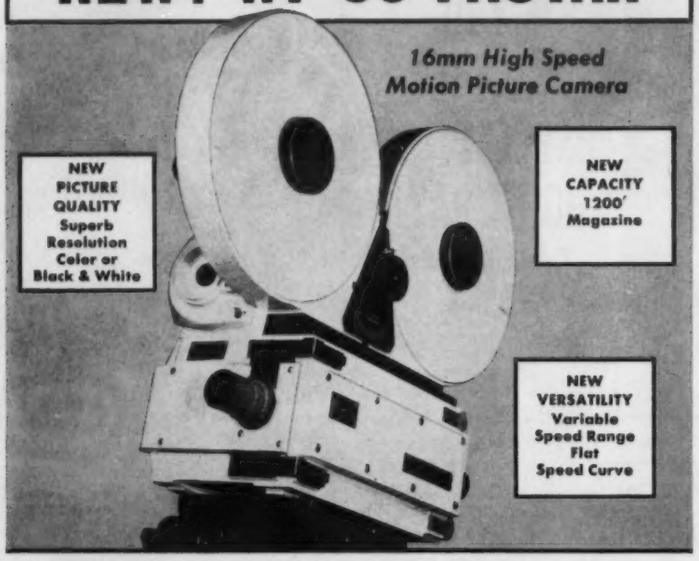
CIRCLE 97 ON READER-SERVICE CARD

NEW! WF-30 FASTAX



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WRITE for complete information and prices on WF-30 . . . the newest FASTAX in the wide line of Wollensak high speed motion picture cameras.

WF-32 OSCILLOGRAPHIC RECORDER

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CIRCLE 98 ON READER-SERVICE CARD

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made of NYLON
WIRE TIES

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For Your Library

Printed Circuitry **$2.00**

by Allan Lytel. A valuable working tool; includes alternative and recommended practice for each step in design and production of printed circuits; a buyer's guide to special components; and "how to" service data. Paperbound, illustrated, 192 pages, 1957.

Instruments Publishing Co.
845-Ridge Ave. Pgh. 12, Pa.

IN-LINE READOUT devices, including edge-lighted, projected image, spherical optic display, electro-mechanical, electroluminescent and NIXIE Indicator tubes are compared in new 14-page bulletin "Readout Fact Finder".—Burroughs Corp., Electronic Tube Div., Plainfield, N. J.

CIRCLE 284 ON READER-SERVICE CARD

LINEAR DIFFERENTIAL Transformers, transducers which produce an ac voltage proportional to the displacement of their moving element from the electrical center, are listed with typical applications in new 12-page bulletin 6208.—Automatic Timing & Controls, Inc., King of Prussia, Pa.

CIRCLE 285 ON READER-SERVICE CARD

RELAYS for general purpose applications are described in 8-page booklet, GH Series.—Elgin Advance Relays, Electronics Div., Elgin National Watch Co., 2435 North Naomi St., Burbank, Calif.

CIRCLE 286 ON READER-SERVICE CARD

ROTARY RELAY, subminiature Couch type 4D, is described with complete mechanical, electrical and environmental data in 2-page Data Sheet.—Couch Ordnance, Inc., 3 Arlington St., North Quincy 71, Mass.

CIRCLE 287 ON READER-SERVICE CARD

FERRITE MICROWAVE components and sub-assemblies, are listed with characteristics in 4-page catalog C-5.—Caswell Electronics Corp., 414 Queens Lane, San Jose 12, Calif.

CIRCLE 288 ON READER-SERVICE CARD

WAVEGUIDE COMPONENTS, including flexible and twistable waveguides—are described in new wall-hanging catalog No. 16.—Microtech, Inc., 1425 Milldale Rd., Cheshire, Conn.

CIRCLE 289 ON READER-SERVICE CARD

MAGNETRON, KuBand Fixed frequency Model BLM-071, characteristics are listed in 2-page catalog Data Sheet.—BOMAC Laboratories, Inc., Salem Rd., Beverly, Mass.

CIRCLE 290 ON READER-SERVICE CARD

PI-LINE Variable attenuators and other ARRA Microwave components are described in series of six 2-page bulletins.—Antenna and Radome Research Associates, 27 Bond St., Westbury, N. Y.

CIRCLE 291 ON READER-SERVICE CARD

WAVEGUIDE Adapters of many available configurations and sizes from WR28 to WR90 are illustrated and listed by number and dimension in new 19-page catalog JS-61A. Handy Cross Reference converts old model numbers to new model numbers.—Microwave Development Laboratories, Inc., 15 Strathmore Rd., Natick Industrial Center, Natick, Mass.

CIRCLE 292 ON READER-SERVICE CARD

MICROWAVE DIODES for mixer and video detector applications are listed in 4-page catalog DM-'61.—Microwave Development Laboratories, Inc., 15 Strathmore Rd., Natick Industrial Center, Natick, Mass.

CIRCLE 293 ON READER-SERVICE CARD

SIDEWALL HYBRIDS, over 100 short-slot types are described in new 12-page catalog HS61.—Microwave Development Laboratories, Inc., 15 Strathmore Rd., Natick Industrial Centre, Natick, Mass.

CIRCLE 294 ON READER-SERVICE CARD

RF ATTENUATOR characteristics of seven variable types covering ranges from 0 to 500mc are described in new 2-page catalog sheet.—Ortho Filter Corp., Subsidiary of Ortho Industries, Inc., 7 Paterson St., Paterson 1, N. J.

CIRCLE 295 ON READER-SERVICE CARD

"CHIRP" RADAR technique using pulse compression networks to get optimum radar pulse shape is described in 2-page catalog sheet.—Ortho Filter Corp., subsidiary of Ortho Industries, Inc., 7 Paterson St., Paterson 1, N. J.

CIRCLE 296 ON READER-SERVICE CARD

MICROWAVE COMPONENTS, over 200 standard precision microwave components, covering a range from 1.70 to 40 gc, with all units calibrated on instruments traceable to the National Bureau of Standards, are described in new 8-page catalog.—Microwave Components and Systems Corp., 1001 S. Mountain Ave., Monrovia, Calif.

CIRCLE 297 ON READER-SERVICE CARD

STERLING *Components*
a division of STERLING PRECISION CORPORATION

DIFFERENTIALS

The largest single source of standard Precision Electro-Mechanical Components.

SPEED REDUCERS
CLUTCHES
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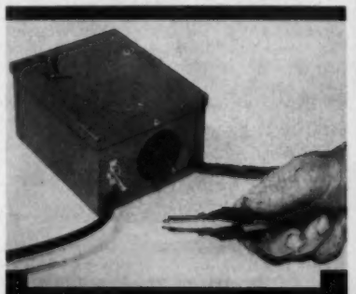
CIRCLE 100 ON READER-SERVICE CARD



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TINY-THERM

TEFLON WIRE STRIPPER

Smallest available thermal stripper • Strips Teflon clean and nick-free • Useful in the most inaccessible areas • Tweezer action with ⅛" tip width • Strips #40-#20AWG — No adjustment • Continuously-variable heat control • Six other models from $22.95 to $395.00 • Send wire samples for recommendations.

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Western Electronic Products Co.
2420 North Lake Avenue, Altadena, Calif.

CIRCLE 101 ON READER-SERVICE CARD

MICROWAVE Test Instruments, including spectrum analysis, reception, field intensity, signal generation and other laboratory equipment, are described in new 10-page catalog digest '61.—Polarad Electronics Corp., 43-20 34th St., Long Island City 1, N. Y.

FOR THIS LITERATURE CIRCLE 298 ON READER-SERVICE CARD

WAVEGUIDE precision machined fittings are specified in new 4-page brochure.—PEM Machine Tool Co., Inc., 1456 Chestnut Ave., Hillside, N. J.

FOR THIS LITERATURE CIRCLE 299 ON READER-SERVICE CARD

MICROWAVE ANECHOIC chambers for simulating free space antenna ranges are described in new 12-page Eccosorb® brochure which pictures 14 new designs.—Emerson & Cuming, Inc., Canton, Mass. or 604 West 182nd St., Gardena, Calif.

FOR THIS LITERATURE CIRCLE 300 ON READER-SERVICE CARD

MICROWAVE COMPONENTS, including rigid coax transmission lines, antennas, waveguide, accessories components and systems are described with engineering data in new 42-page product catalog.—Telerad, Div., of The Lionel Corporation, Route 69-202, Flemington, N. J.

FOR THIS LITERATURE CIRCLE 301 ON READER-SERVICE CARD

SILICON DIODE. High Reliability Master Test Specification, MARK X is described in 4-page brochure.—Rheem Semiconductor Corp., P. O. Box 1327, Mountain View, Calif.

FOR THIS LITERATURE CIRCLE 302 ON READER-SERVICE CARD

GERMANIUM TRANSISTORS, specifications of 452 types are detailed in 8-page catalog.—Electronic Transistors Corporation, 9226 Hudson Blvd., North Bergen, N. J.

FOR THIS LITERATURE CIRCLE 303 ON READER-SERVICE CARD

DIODES, including high-power silicon varactors, low-voltage high-Q varactors, 30-volt varactors, Mixer, video and special purpose types; are described and listed in new catalog 61MS.—Microwave Associates, Inc., Burlington, Mass.

FOR THIS LITERATURE CIRCLE 304 ON READER-SERVICE CARD

TRANSISTOR amplifier specifications of four standard PEC 4-stage packages are detailed in new 4-page bulletin. —Centralab, The Electronics Div. of Globe-Union Inc., 900 East Keefe Ave., Milwaukee 1, Wis.

FOR THIS LITERATURE CIRCLE 305 ON READER-SERVICE CARD

SOLID-STATE Amplifiers for Precision Ground instrumentation, Submin Airborne, Galvo driver and direct coupled applications are listed in short form catalog.—Video Instruments Co., Inc., 3002 Pennsylvania Ave., Santa Monica, Calif.

FOR THIS LITERATURE CIRCLE 306 ON READER-SERVICE CARD

PNP SILICON Alloy transistors types 2N1228 to 2N1234 inclusive, for switching and amplifying use at moderate speeds and at low and medium current levels are described in new 2-page catalog sheet.—Sperry Semiconductor Div., Sperry Rand Corporation, Norwalk, Conn.

FOR THIS LITERATURE CIRCLE 307 ON READER-SERVICE CARD

MICROCIRCUITRY DEVICES now available as standard digital, computer, control and audio circuits are described in new 18-page catalog.—Varo Inc., 2201 Walnut St., Garland, Texas.

FOR THIS LITERATURE CIRCLE 308 ON READER-SERVICE CARD

SEMICONDUCTOR 4-layer device called the Dynaquad is described with switching characteristics in new 4-page brochure.—Tung-Sol Electric Inc., 1 Summer Ave., Newark 4, N. J.

FOR THIS LITERATURE CIRCLE 309 ON READER-SERVICE CARD

NANOCIRCUITS, subminiature modular circuits are described in new 8-page bulletin NC-10.—General Instrument Corp., Semiconductor Div., 600 W. John St., Hicksville, N. Y.

FOR THIS LITERATURE CIRCLE 310 ON READER-SERVICE CARD

TIME DELAY circuits, with the Shockley 4-layer diode as the active element, and having a practical delay range from 10 μsec to 30 min are described in new 5-page application bulletin.—Shockley Transistor unit of Clevite Transistor, Stanford Industrial Park, Palo Alto, Calif.

FOR THIS LITERATURE CIRCLE 311 ON READER-SERVICE CARD

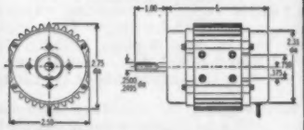
DIGITAL Logic Module application information for use of shift registers, accumulators and counters is given in new 16-page catalog for 1200 series modules.—Computer Techniques Inc., 3300 Northern Blvd., Long Island City 1, N. Y.

FOR THIS LITERATURE CIRCLE 312 ON READER-SERVICE CARD

AC

Thousands of these precision motors from Air Marine have been used both by the military and industry. The "E Frame" shown below is offered in either induction or hysteresis synchronous versions.

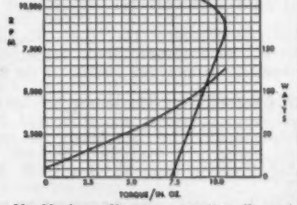
"E FRAME" (Finned)
3.68" Overall Length
For Continuous Duty Application



Induction
200 V., 3 phase 400 cycle
1/10 H. P. at 10,500 RPM
Torque, Starting 7.3" oz.
Torque, Running 9.0" oz.
Insulation to specs.

Hysteresis
115 V., 1 phase 400 cycle
Sync. Speed 8000 RPM
Starting Torque 3.0" oz.
Pull-in Torque 2.6" oz.
Pull-out Torque 2.7" oz.
Locked Rotor Current .92 amps

TYPICAL INDUCTION CURVES



Air Marine offers a complete line of fractional AC motors, blowers and fans. Motors range in size from 1/1000 to 1/2 H. P. 400 cycle units are designed for airborne application. Specify your needs and let Air Marine deliver.

air marine motors, inc.
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CIRCLE 102 ON READER-SERVICE CARD

Top Two Together

Complete Line Now Available

Air Marine Motors of Amityville, New York and Motordyne of Los Angeles, California have combined to offer industry an extensive line of both AC and DC motors in the fractional horsepower range. Motors from these companies have for years fulfilled the requirements of both industry and military. The wide variety of types offered makes this source invaluable to the design engineer. Comprehensive literature on units to fulfill specific needs is available from either the east or west coast facilities.

Quality is a Statistic

Motors from Air Marine and Motordyne have gained a reputation of reliability based on the quality of performance. Numerous units designed for the military have continually met rigid environmental requirements. Hundreds of pages of statistics are available to establish beyond any doubt the ability of these motors to meet all types of specifications.

Research and Development

Laboratories are maintained on both the east and west coasts, under the direction of highly competent engineers who continually probe for more advance techniques in the manufacturing of rotating components. The AC and DC motors of these corporations are continually being studied to increase their life and efficiency. These laboratories also study specific problems of customers relative to motor performance.

Engineering Consultation

The field engineers of Air Marine and Motordyne are trained to assist the customer in the selection and installation of motors. These engineers are often called upon by the customer to assist in specifying the right motor for a specific job. A call to either the east or west coast facility will alert these engineers to your specific problems.

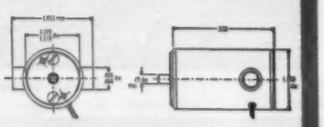
Additional Lines from Air Marine and Motordyne

Now from these extensive facilities a complete line of blowers, fans, governors, brakes, gears, servo motors and thermal overload switches have become available: Complete information is available on request.

DC

Another precision motor from Motordyne capable of meeting the most stringent specifications. Hundreds of planetary gear speed reducers are offered as well as brakes, governors, clutches and thermal overload switches.

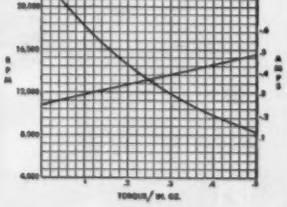
SERIES 1200, REVERSIBLE MOTOR



Power Supply	24-28 volts
Line Current	.5 Max. amps
Speed	10000 RPM
Output	.004 H. P.

Continuous Duty .5" oz.
Intermittent Duty 1.0" oz.

TYPICAL CURVE



If you face a DC motor application problem let a Motordyne field engineer assist in the solution. For prompt attention contact either the East or West Coast facilities.

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a subsidiary of air marine motors, inc.
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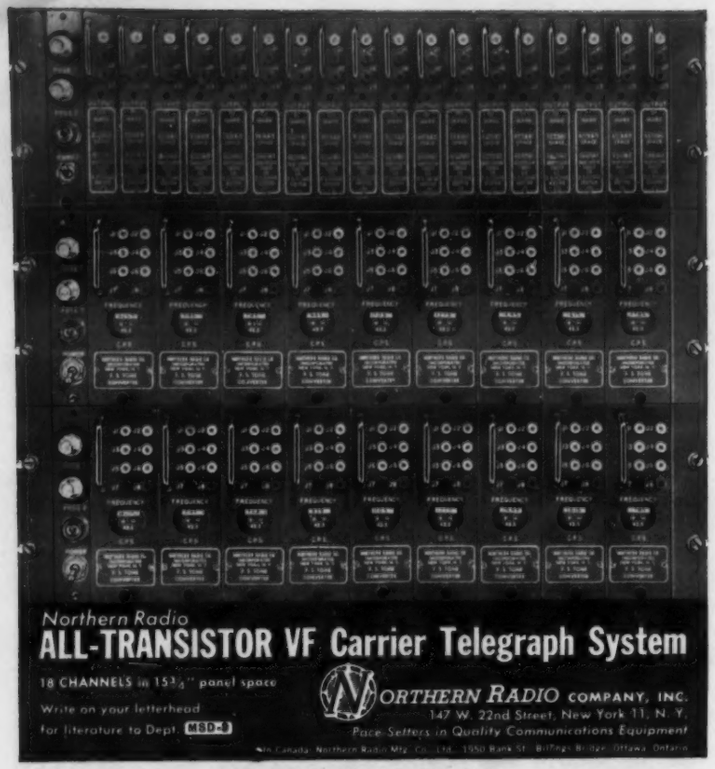
CIRCLE 103 ON READER-SERVICE CARD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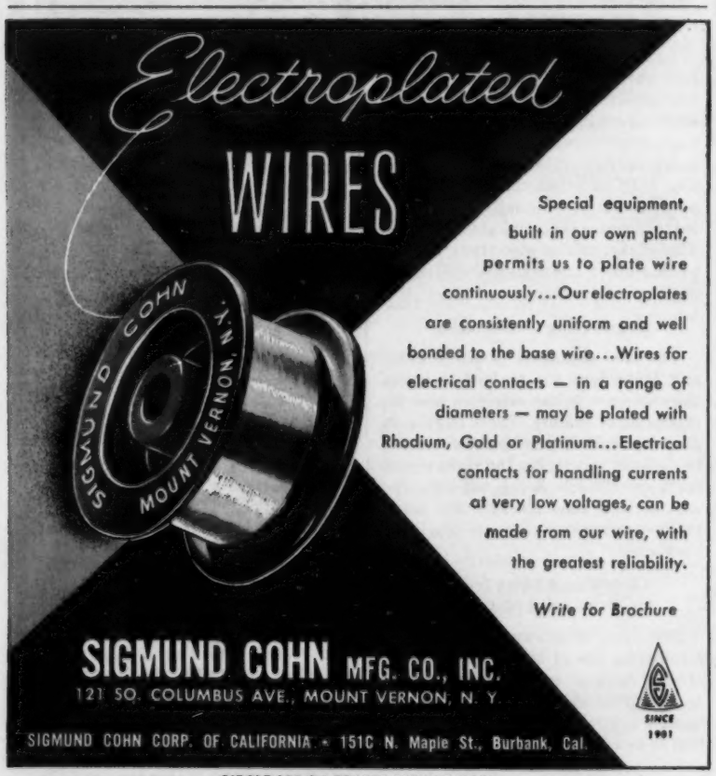
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CIRCLE 105 ON READER-SERVICE CARD

UHF TWIN Power Pentode, RCA6939, is described for class "A" RF amplifier and frequency tripler service up to 500 mc in new 8-page application Note AN-192.—Electron Tube Div., Radio Corp. of America, Harrison, N. J.

FOR THIS LITERATURE CIRCLE 313 ON READER-SERVICE CARD

SEMICONDUTOR Performance certification, what it is and why it is possible for Syntron to provide 18 months guarantee of semiconductor device performance, is discussed in 8-page bulletin 200.—Semiconductor Div., Syntron Co., Homer City, Pa.

FOR THIS LITERATURE CIRCLE 314 ON READER-SERVICE CARD

POWER SUPPLIES. high-voltage dc supplies with 250 kv output at full load of 50 ma are described in 2-page bulletin 5-70.1.—Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill.

FOR THIS LITERATURE CIRCLE 315 ON READER-SERVICE CARD

POWER SUPPLY Model 417A for general purpose applications, rated at 0 to 500 volts, output current 0 to 500 ma, the Model 417A is described in 2-page bulletin.—John Fluke Mfg. Inc., P. O. Box 7428, Seattle 33, Wash.

FOR THIS LITERATURE CIRCLE 316 ON READER-SERVICE CARD

POWER SUPPLY listing by functions and specifications obviates need for overspecifying more expensive equipment to play safe. Hundreds of models are listed in 16-page catalog.—NJE Corporation, 20 Boright Ave., Kenilworth, N. J.

FOR THIS LITERATURE CIRCLE 317 ON READER-SERVICE CARD

SILICON ZENER diodes for voltage regulation in miniature JEDEC Types are described in two 2-page bulletins for 1 watt and 10 watt sizes.—Publications Dept., Fansteel Metallurgical Corp., North Chicago, Ill.

FOR THIS LITERATURE CIRCLE 318 ON READER-SERVICE CARD

SELENIUM rectifiers covering ranges from microamperes to kiloamperes and voltages from millivolts to kilovolts are described in new 8-page bulletin 101.—Edal Industries, Inc., 4 Short Beach Rd., East Haven, Conn.

FOR THIS LITERATURE CIRCLE 319 ON READER-SERVICE CARD

POWER PACKS, in miniature solid-state high-voltage types from 1000 v to 20,000 v dc, in regulated and non-regulated units are described in 2-page catalog sheet.—Electronic Research Associates, Inc., 67 Factory Pl., Cedar Grove, N. J.

FOR THIS LITERATURE CIRCLE 320 ON READER-SERVICE CARD

TUNNEL DIODE Power Source Model TD6M is described in 3-page technical bulletin.—Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N. J.

FOR THIS LITERATURE CIRCLE 321 ON READER-SERVICE CARD

HV POWER SUPPLY, RF unit supplying continuously variable dc outputs in 10-40kv range is described in 2-page catalog sheet C-1.—MIKROS, Inc., 7620 S. W. Macadam Ave., Portland 19, Ore.

FOR THIS LITERATURE CIRCLE 322 ON READER-SERVICE CARD

DC-TO-DC CONVERTER for missile computers providing +15v, −15v, +6v and 6v from 28v dc input is described in 2-page bulletin 146-26-2.—Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif.

FOR THIS LITERATURE CIRCLE 323 ON READER-SERVICE CARD

SILICON RECTIFIERS, Miniature hermetically-sealed types SLA536 to SLA540, SLA109 and SLA1096, designed to replace larger top hat types of corresponding IN-numbered units, are described in new 2-page data sheet.—Slater Electric Inc., 45 Sea Cliff Ave., Glen Cove, L.I., N. Y.

FOR THIS LITERATURE CIRCLE 324 ON READER-SERVICE CARD

INDICATOR POWER SUPPLY, for providing supply and bias voltages for TEC-LITE transistorized and conventional neon indicators, is described in new 2-page data sheet LPS.—Transistor Electronics Corp., 3357 Republic Ave., Minneapolis 26, Minn.

FOR THIS LITERATURE CIRCLE 325 ON READER-SERVICE CARD

REGULATED Power Supplies are described in detail in new 1961 long form 44-page catalog.—Harrison Laboratories, Inc., 45 Industrial Rd., Berkeley Heights, N. J.

FOR THIS LITERATURE CIRCLE 326 ON READER-SERVICE CARD

PLUGIN POWER Supplies in 19 transistorized models are described in new 4-page brochure.—Acopian Technical Co., 927 Spruce St., Eaton, Penna.

FOR THIS LITERATURE CIRCLE 327 ON READER-SERVICE CARD

DRY TRANSFER LETTERING

Instant Lettering brings you the finest, most meticulous lettering in the world instantly—by instantaneous dry transfer from type sheet to any smooth surface. Just press and it's there.
No trace of adhesive to sully artwork. Needs no equipment. Perfect on wood, paper, card, glass, metal, film . . . in fact any smooth surface. The right answer to the need for highest quality lettering for display panels, roughs, signs, labels, graphs, charts, TV cells.

10" x 15" SHEET ONLY $1.50

How it works:
rub on letter with pencil . . . lift away sheet
Send for sample and complete type chart

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CIRCLE 106 ON READER-SERVICE CARD

Portable Thyratron Tube Tester Permits Bench Testing Of All Common Industrial Tubes

In operation, the Thyratron under test, functions within the instrument circuit. Meters indicate operating points and permit quick comparison with the tube chart. The instrument automatically indicates critical grid volts, and current. It accommodates tubes 0.1 thru 16 amps. Input is 105 to 130 volts AC single-phase 60-cycle.

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PRESTO-SPLICE DIGITAL TAPE IN 1/2 SECONDS

No Adhesives — No Drying Time Required
Perfect Tape Alignment Assured Every Time

- Collect short-ends of information on large reel for single run.
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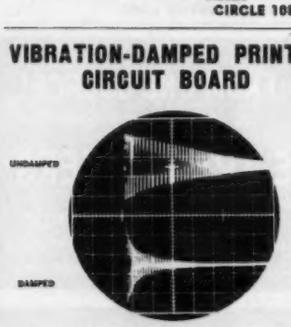
CIRCLE 108 ON READER-SERVICE CARD

VIBRATION-DAMPED PRINTED CIRCUIT BOARD



New Dyna-damp® epoxy-fiberglass laminated with BTR® elastomer and copper cladded provides unique material for printed circuit base which attenuates resonant structural response. Bulletin 719 describes.—*Lord Mfg. Co., Erie, Pa.*

CIRCLE 328 ON READER-SERVICE CARD

CIRCULATING BALL SLIDE

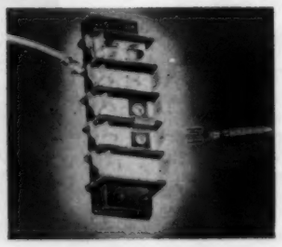
New Model CBV ultra-thin circulating ball slide uses a vertical bearing race to allow standard chassis width. Effortless sliding action with loads to 500 lb capacity is assured. Sizes from 16" to 24" mount with standard hardware to fit any standard rack or cabinet.—*Chassis-Trak, Inc., 525 South Webster Ave., Indianapolis 19, Ind.*

CIRCLE 329 ON READER-SERVICE CARD

SELF-LOCKING TERMINALS

New self-locking, quick disconnect wire terminations of Kulka terminal blocks are now available for up to six connections per stage. Vari-angled "Kliptite" tabs accept female wire terminations made by AMP, Burndy, Kent, and Arkles and supplied singly or in rolls for automatic machine assembly.—*Kulka Electric Corp., 633-643 So. Fulton Ave., Mount Vernon, N. Y.*

CIRCLE 330 ON READER-SERVICE CARD



CABLES, military hook-up wires, computer constructions and semi-rigid vinyl insulated wires, military air frame wires, and vinyl jacketed cables are described in new 12 page facilities brochure.—Brand-Rex Div., American Enka Corp., 18120 So. Broadway, Gardena, Calif.

FOR THIS LITERATURE CIRCLE 331 ON READER-SERVICE CARD

TERMINAL ASSEMBLY time study, a 10-page report showing production ratios for various types of terminal connections in electronic manufacturing, is available on request.—Marketing Dept., Pacific Coast Electronics Corp., 2457 Chico Blvd., S. El Monte, Calif.

FOR THIS LITERATURE CIRCLE 332 ON READER-SERVICE CARD

CABLE ASSEMBLIES in Neoprene or Polyvinyl Chloride jackets for waterproof protection tailored to customer requirements are described in new 4-page brochure.—Electro-Mechanics, Inc., 160 Whiting St., New Britain, Conn.

FOR THIS LITERATURE CIRCLE 333 ON READER-SERVICE CARD

PRINTED CIRCUIT Variations, including flexible, flush, multilayer and new "Carte Blanche" standardized printed circuit cards are described in new 12-page bulletin "Depth in Circuitry."—U. S. Engineering Co., 13536 Saticoy St., Van Nuys, Calif.

FOR THIS LITERATURE CIRCLE 334 ON READER-SERVICE CARD

CONTAINERS for Polaris Sub-System packaging per BUWEPS DRWG List 2210448 are listed in new 8-page catalog D1 supplement.—Zero Manufacturing Co., 1121 Chestnut St., Burbank, Calif.

FOR THIS LITERATURE CIRCLE 335 ON READER-SERVICE CARD

AIR MOVING in electronic equipment at silent 100 cfm capacity rate is described in new 4-page Gold Seal Catalog E-2800.—Rotron Mfg. Co., Inc., Woodstock, N. Y.

FOR THIS LITERATURE CIRCLE 336 ON READER-SERVICE CARD

HEAT SINKS and Dissipators are described with graphs, curves, tests and detail drawings to case outlines in new 8-page catalog.—Vemaline Products Co., Franklin Lakes, N. J.

FOR THIS LITERATURE CIRCLE 337 ON READER-SERVICE CARD

RHENIUM and Rhenium alloy fabrication, varieties and application are detailed in new 12-page brochure.—Rhenium Div., Chase Brass & Copper Co., Waterbury, Conn.

FOR THIS LITERATURE CIRCLE 338 ON READER-SERVICE CARD

CERAMIC-TO-METAL housings for high-power high-current semiconductor rectifiers are described in 2-page data sheet.—Advanced Vacuum Products, Inc., 430 Fairfield Ave., Stamford, Conn.

FOR THIS LITERATURE CIRCLE 339 ON READER-SERVICE CARD

INSULATING Tubings and sleevings for Class A through Class H temperature applications are described in new 12-page booklet.—Irvington Div., Minnesota Mining and Manufacturing Co., St. Paul, Minn.

FOR THIS LITERATURE CIRCLE 340 ON READER-SERVICE CARD

CERAMIC Cellular CERCOR, a new family of thin walled ceramic materials withstanding temperatures over 1000°C, thermal shock and chemically inert is described in new 6-page brochure NPC-2.—New Products Div., Corning Glass Works, Corning, N. Y.

FOR THIS LITERATURE CIRCLE 341 ON READER-SERVICE CARD

SILICONE RUBBER, Its uses and abuses, is title of interesting, objective 60-page free book on characteristics and applications.—Mechanical Rubber Products Co., Warwick, N. Y.

FOR THIS LITERATURE CIRCLE 342 ON READER-SERVICE CARD

SILICONE RUBBER properties and handling characteristics as applied to wire and cable insulation in aircraft and missile support equipment is described in new 4-page tech bulletin CDS-158.—Silicone Products Dept., General Electric, Waterford, N. Y.

FOR THIS LITERATURE CIRCLE 343 ON READER-SERVICE CARD

TOP HAT retainers for tubes and other plug-in components are described in three 2-page bulletins; 5.2, 5.3 and 5.4.—Westrex Communication Systems, 540 West 58th St., New York 19, N. Y.

FOR THIS LITERATURE CIRCLE 344 ON READER-SERVICE CARD

IR CELL Cooling systems are described in new 20-page catalog.—Linde Company, Div. of Union Carbide Corp., 270 Park Ave., New York 17, N. Y.

FOR THIS LITERATURE CIRCLE 345 ON READER-SERVICE CARD

NEUTROLOY ultra-fine wire and other copper-nickel alloy resistance wires are described in new 4-page bulletin.—Molecu Wire Corp., Eastontown-Freehold Pike, Scobeyville, N. J.

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- power supplies included—no battery replacement or checks needed
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303-1 AC TRVM	2½"	50% less panel area than Model 301-1	275.00
304-1 AC TRVM	2½"	zero-center, phase sensitive, from ± 10MV	300.00
305-1 DC TRVM	3½"	zero-center, no zero-set, ± 100MV range	225.00
305-2 DC TRVM	3½"	zero-left version of 305-1, 250MV range	225.00

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MINI AXIAL BLOWER

New miniature axial blower operating from 117v 60 cps single phase power delivers 15 cfm @ 0.2 H_2O. Continuous life is rated over 2500 hrs, weight is only 12 oz.—*Globe Industries, Inc.*, 1784 *Stanley Ave., Dayton, Ohio.*

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MINI HI-TEMP CABLES

New miniature high temperature coaxial cables included in MIL-C-17C are RG-178B/U, RG-179B/U and RG-180B/U in Teflon FEP jackets which permit operation up to 200°C. Also RG-187A/U, RG-188A/U, RG-195A/U and RG-196A/U are now available with annealed center conductors (8% minimum elongation) to permit greater tensile loads.—*Times Wire & Cable Co., Inc., Wallingford, Conn.*

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New "Press-Rit" Teflon RFT-SM-18 TUR-L12 subminiature reverse feedthru provides a termination for easy use of alligator test clips or where the 90° turn permits a straight or axial wiring run from the terminal.—*Sealecto Corporation*, 610 *Fayette Ave., Mamaroneck, N. Y.*

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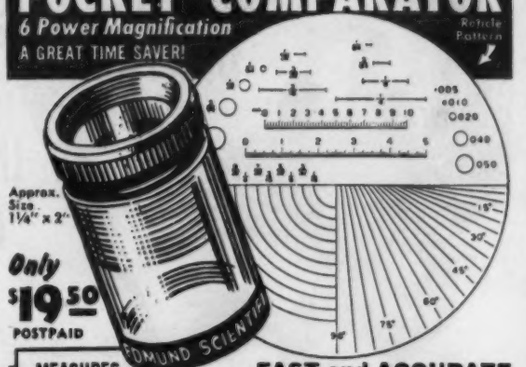

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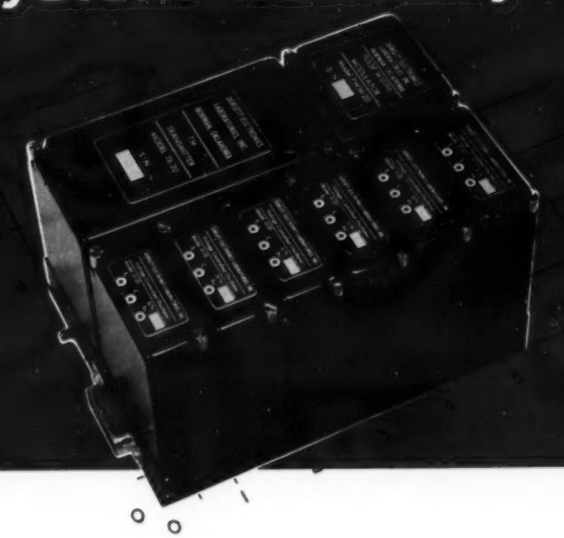

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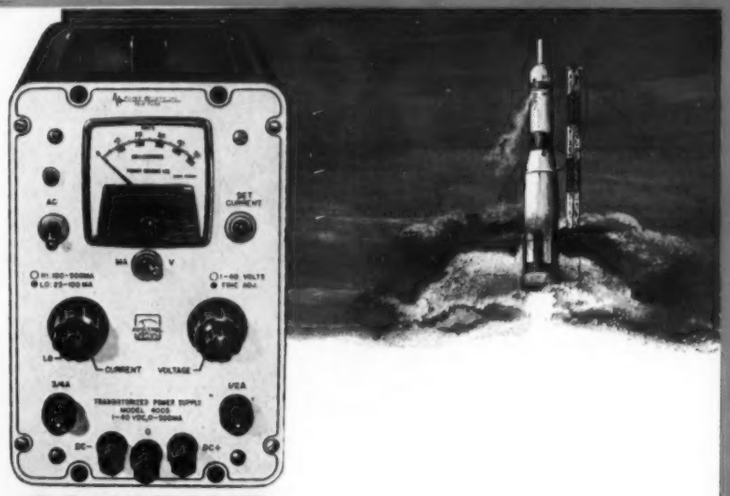

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Ripple: .0005% or 250 microvolts maximum.

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Source Z: 0.1 ohms to 20 kc, 0.7 ohms to 1 mc.

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Ripple Content: .005% or 20 microamperes max.

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Ripple: .0005% or 250 microvolts maximum.

Response Time: Less than 50 microseconds.

Source Z: 0.1 ohms to 20 kc, 0.7 ohms to 1 mc.

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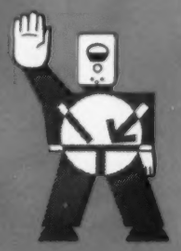

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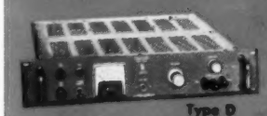

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105-155VDC÷0-1.0A
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REGULATION: .05%
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MSD events

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NOVEMBER 14-16—Northeast Electronics Research and Engineering Meeting (NEREM), Commonwealth Armory and Somerset Hotel, Boston, Mass. Write Lewis Winner, 152 West 42nd St., New York 36, N. Y.

NOVEMBER 20-21—Electron Devices Meeting, PGED-IRE, Shoreham Hotel, Washington, D. C.

JANUARY 9-11—8th National Symposium of Reliability and Quality Control, Statler-Hilton Hotel, Washington, D. C. Sponsored by ASQ, IRE, AIEE and EIA. Write A. R. Park, Westinghouse Elec. Corp., Box 1897, Baltimore 3, Md.

NOVEMBER 6-8—Sixth Annual Special Conference on Non-Linear Magnetics, Statler Hilton Hotel, Los Angeles, Calif. Sponsored by AIEE and IRE. Write Dr. T. Bernstein, Space Technology Labs., P. O. Box 95001, Los Angeles 45, Calif.

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